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Nutritional Composition of Australian Combat Ration Packs and Options for Improvement

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ABSTRACT

Health Systems Program Office (HLTHSPO), Defence Materiel Organisation (DMO) requested the Defence Science and Technology Organisation (DSTO) to verify the requirement for fortification of Combat Ration (CR) components and identify options to improve the nutrient composition of Combat Ration Packs (CRP). This report is based primarily on the nutritional composition analysis of the 2008-09 build of CRP, prior to the commencement in 2010 of HLTHSPO program of continuous improvement activities for CRP. In the 2008-09 build, a number of nutrients were not present at recommended levels. Priority should be given to rectifying inadequate levels of protein, folate, vitamin B6, vitamin A, vitamin E, vitamin K, iron and calcium. The availability of thiamin, vitamin B12 and vitamin C is of some concern and improvements are needed. The vitamin D content of CRP should be assessed as levels are currently unknown.

The findings will inform HLTHSPO's ongoing CRP improvement program. Options to improve the nutritional quality of CRP include: re-configuration of the suite of rations; Defence specific component formulation (Military-Off-The-Shelf); increased use of Commercial-Off-The-Shelf products; fortification; and combinations of these options.

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Nutritional Composition of Australian Combat Ration Packs and Options for Improvement

Executive Summary

In 2008/09, DMO's HLTHSPO and DSTO commenced a five-stage quality assurance program to evaluate the nutritional and shelf life adequacy of Combat Rations (CR) components. DSTO provides HLTHSPO with advice progressively as results became available, thereby establishing a scientific basis for ongoing improvements to the suite of CR components. A matter of particular interest is the requirement for fortification of CR components. HLTHSPO has requested that DSTO verify this requirement.

In this report, the nutritional value of CR components and complete ration packs are estimated and evaluated. The results are based, primarily, on the analysis of components in use prior to HLTHSPO implementing significant changes to the suite of CR components. The report discusses options for improvement, one of which is fortification.

Historically the fortification of CR components has been used to ameliorate problems associated with Combat Ration Pack (CRP) feeding. This includes: vitamin losses during processing and storage, selective consumption of ration components by troops, uneven distribution of nutrients across CR components and naturally low levels of certain vitamins.

For the purpose of this investigation, the nutrients of interest were: protein, thiamin, riboflavin, niacin, folate, vitamin B6, vitamin B12, vitamin C, vitamin A, vitamin D, vitamin E, vitamin K, iron and calcium. These were selected based on importance to soldier health and performance, ongoing concern about levels in CRP, specified requirements, adequacy and availability of data, and degree of interest to the general population.

Pre-storage nutrient content (representing the condition at time of receipt by Defence[1]) was assessed against the Recommended Nutritional Criteria[2] for general purpose ration packs. Post-storage nutrient content (approximating the condition at time of consumption) was assessed against the Military Recommended Dietary Intakes.

[1] This is the time that Defence receives components for consolidation into CRP.

This report presents evidence that the CRP evaluated in this study, did not fully meet nutritional guidelines and provides some practicable options for improvement. This information will be of value to HLTHSPO as it seeks to improve CRP and may be used as a reference point for a future assessment of the impact of those improvements.

Priority should be given to rectifying inadequate levels of protein, folate, vitamin B6, vitamin A, vitamin E, vitamin K, iron and calcium. There are also concerns about the current levels of thiamin, vitamin B12 and vitamin C due to the reliance of adequate intake being dependent on the consumption of certain components. The vitamin D content of CRP should be assessed as levels are currently unknown. The fortification of the main meal items, ration chocolate and sports beverage powder, as per current requirements, remains warranted at this time.

Options to improve the nutritional quality of CRP to meet nutrient specifications include: re-configuration of the suite of rations; Defence specific component formulation (Military-Off-The-Shelf – MOTS); increased use of Commercial-Off-The-Shelf (COTS) products; fortification (MOTS, COTS, ingredients); and combinations of these options.

Detailed recommendations is provided in the main body of the report.

Authors

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In 2008 Bianka graduated from Deakin University with a Graduate Diploma in Human Nutrition and in 2009 became a Registered Nutritionist with the Nutrition Society of Australia. In 1999 Bianka completed a B App Sc (Hons) in biotechnology and biochemistry at LaTrobe University. She is currently undertaking a Master of Public Health (Nutrition) through Curtin University. Bianka has been employed at DSTO-Scottsdale since 1999 working in the fields of food technology, microbiology, biochemistry and nutrition. Bianka is interested in the application of public health nutrition to improve the general health and wellbeing of members of the Australian Defence Force. She is currently working on the implementation of a draft Fresh Feeding Scale and improving the nutritional quality of Combat Ration Packs.

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Lan has been employed at DSTO-Scottsdale since 2004. Her R&D work experience has been in the fields of food science and technology and food chemistry, with particular interests in food fortification, microencapsulation, product development and food analysis. She graduated from Victoria University, Melbourne (VUT) firstly with BSc (Hons) and then a PhD in Food Science and Technology in 2004. She is a Professional Member of the Institute of Food Technologists (IFT).

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Abbreviations

ADF	Australian Defence Force
ADFFS	Australian Defence Force Food Specifications
ADFFSC	Australian Defence Force Food Specifications Committee
ADFRS	Australian Defence Force Ration Scale
ADFRSC	Australian Defence Force Ration Scales Committee
CFI	Centre for Food Innovation
the Code	The Food Standards Code
COTS	Commercial-Off-The-Shelf
CR	Combat Ration
CR1M	Combat Ration One Man
CRP	Combat Ration Pack
DMO	Defence Material Organisation
DSTO	Defence Science and Technology Organisation
FD	Freeze Dried
FSANZ	Food Standards: Australia and New Zealand
FSB	First Strike Bar ™
HLTHSPO	Health Systems Program Office
MOTS	Military-Off-The-Shelf
MRDI	Military Recommended Dietary Intake
PIFs	Product Information Forms
RNC	Recommended Nutritional Criteria
QA	Quality Assurance
SASR	Special Air Services Regiment
S&T	Science and Technology
TGA	Therapeutic Goods Administration
USA	United States of America
USARIEM	United States Army Research Institute of Environmental Medicine

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1. Introduction

1.1 Background

Health Systems Program Office (HLTHSPO), Defence Materiel Organisation (DMO) is responsible for the procurement and in-service management of Combat Rations (CR). The Defence Science and Technology Organisation (DSTO) provides Science and Technology (S&T) support to assist DMO in this role. In 2008/09, HLTHSPO and DSTO commenced a quality assurance program (QA) to evaluate the nutritional and shelf life adequacy of CR components. Due to the effort that would be involved, a rolling QA program was developed to analyse all CR components in five stages over a period of approximately seven years[3]. DSTO provides HLTHSPO with advice progressively as results became available, thereby establishing a scientific basis for ongoing improvements to the suite of CR components.

A matter of particular interest is the requirement for fortification of CR components. HLTHSPO has requested that DSTO verify this requirement. Historically, a limited range of components has been fortified to ensure the provision of adequate amounts of vitamins; this included allowance for vitamin degradation between manufacture and the time of consumption. The specification and purchase of bespoke components incurs a cost premium and limits choice by precluding the use of commercial-off-the-shelf (COTS) products, therefore it is important to review and verify this requirement from time to time.

This report is based primarily on the nutritional composition analysis of the 2008-09 build of Combat Ration Packs (CRP). HLTHSPO has since 2010 been engaged in continuous improvement activities for CRP. Apart from progressive increase in nutritional content, there have been quality upgrades in product formulation as well as packaging to increase shelf life, inclusion of more acceptable and popular commercial brands, and contracting state-of-the-art processing facilities to ensure safety and quality of the finished products (T Quinn [HLTHSPO, DMO] 2013, pers. comm., 26 August). The changes to CRP since 2008/09 and how they are accepted by ADF members, are being evaluated and will be reported on in due course.

1.2 Combat Rations

Service rationing has been designed to provide nutritionally adequate diets suitable for ADF personnel working in operational and non-operational environments [1]. Service rationing can take the form of: fresh food, canned equivalents (including retort pouches), CR (Emergency Combat Rations and Combat Ration Packs (CRP)), or any combination of these depending on the working environment. In all environments, it is paramount that ADF personnel are fed to the highest standard, using fresh rations wherever possible. CR are normally issued when the situation precludes the use of fresh or canned equivalent foods or when normal cooking facilities are unavailable. This may occur during both operational and non-operational activities [1].

[3] Each stage involved an initial determination of nutrient content followed by a 2 year storage period followed by a second determination of nutrient content.

When consumed in their entirety, Australian CRP are intended to be nutritionally adequate to sustain an individual over extended periods when working at moderate activity levels [2]. CRP are not designed to sustain personnel for greater than 16 days when they are under prolonged, high levels of activity. In such cases there can be some detriment to operational effectiveness as a result of accumulated nutritional shortfalls. Maximum periods of sole CRP consumption are stipulated for both non-operational and operational conditions, with a maximum of 20 days stated for operational environments. However, under emergency conditions ('worst-case scenario') CRP may be the sole food source 'as necessary'. A period of recovery feeding with fresh rations is also required when the maximum period of CRP feeding has occurred. This is based on the length of time that CRP has been the sole source of nutrition. Once the period of fresh feeding has occurred, CRP can again be issued as the sole food source [1].

It has been reported that soldiers are concerned some units no longer have catering staff and that the ability to transition from CRP to fresh rations is being lost. These soldiers also reported that they had spent long periods eating CRP as their main source of food. Periods of three, four and six weeks were often reported, mainly during operations, but also during training exercises. Many expressed concern that periods of CRP feeding were unnecessarily long [3]. Internal DSTO data indicates that during Operation Warden in East Timor in 1999, troops were fed largely or exclusively with CRP for up to 40 days before fresh food could be supplied. Another internally published DSTO study found that during Operation Slipper—in Afghanistan in 2002—Special Air Services Regiment (SASR) troops were rationed almost exclusively on CRP for approximately 120 days before fresh food supplementation was provided.

Under-consumption of CRP is common and widespread among troops during operations [4]. Much of this under-consumption is due to the discard of ration components [5], other factors, such as environmental and behavioural aspects, also contribute to this phenomenon [6]. When soldiers are issued ration packs for long periods, they tend to eat less over time, often losing their appetite and getting menu fatigue [3]. During periods of hard physical work, soldiers may need to make a conscious effort to consume sufficient food as it is often difficult to eat a large amount of food straight after a demanding task [3]. A number of studies have found that during operations and field exercises soldiers suffer from an energy deficit of 10–50% [5, 7, 8]. Vitamin and mineral deficiencies have also been associated with CRP feeding under these circumstances [5, 9].

1.3 Fortification

Food fortification—the addition of vitamins and minerals to foods—has played an important role in reducing common nutrient deficiencies throughout the world [10, 11]. The potential benefits of fortification—improved nutrient intakes and consequential health benefits—has resulted in the mandatory fortification of various foods in a number of developed and developing countries [10-12]. In Australia, for example, the fortification of bread-making flour with thiamin, folate and iodine is mandatory [13].

It is important that CRP provide adequate quantities of nutrients. Historically, fortification of CR components has been used to ameliorate problems associated with CRP feeding.

This includes vitamin losses during processing and storage, selective consumption of CR components by soldiers, uneven distribution of nutrients across the range of components and naturally low levels of certain vitamins. The fortification requirements were initially recommended by the Australian Defence Force Food Specifications Committee (ADFFSC) with the principle aim of providing sufficient levels of key nutrients to meet the needs of ADF consumers.

The fortification requirements are specified in the Australian Defence Force Food Specifications[4] (ADFFS), however these were set more than 20 years ago and need to be reviewed in light of new information [4, 14] and changes to military operations. Additionally, over the intervening years, there have been changes in CRP menus, component types, component formulations, processing technologies, serve sizes, packaging materials and storage conditions. These changes may also impact on the initial levels and storage stability of key nutrients, and potentially increase or decrease the need for fortification.

Similarly, current CRP distribution practices have reduced the historically lengthy delay between component manufacture and consumption by the soldier. The impact of this on shelf life requirements should be assessed. However, while that is an important and ultimately relevant matter, it is not the focus of the current study.

1.4 Approach

The aim of this work was to evaluate the nutritional adequacy of CRP and to provide options, including fortification, to address inadequacies. Although there are three types of CRP currently in use, this report focuses on the nutritional composition of the Combat Ration One Man (CR1M). This is the most widely used CRP and nutrient data is readily available for important components.

For the purpose of this investigation, specific nutrients were selected following consideration of:

Criticality to soldier health and performance;

- History of concern regarding the levels of some nutrients in CRP;
- Specified requirements for nutrients;
- Availability and adequacy of data; and
- Interest to the wider ADF population.

The nutrients of interest were: protein, thiamin, riboflavin, niacin, folate, vitamin B6, vitamin B12, vitamin C, vitamin A, vitamin D, vitamin E, vitamin K, iron and calcium. Protein is the only macronutrient covered in this report. The protein content of CRP is known to be close to and at risk of not meeting the specified minimum requirement,

[4] The ADFFS for CRP components is being revised and replaced by a series of standards and specifications in the DEF(AUST) format. The new specifications include fortification requirements for a range of components.

therefore closer examination is warranted. Although there is no data on the vitamin D content of CR components, it has been included in this report due to concerns about the vitamin D status of the general population, which is likely to be reflected in the Australian military population.

Nutrient data at two time points was compared to assess the effects of storage on the nutritional quality of CR components. The first time point was taken to represent the status of CR components as received by Defence, whilst the second time point represented the end of the warranty period[5] and was assumed to be the time of consumption.

1.5 Data collection and analysis

The nutrient data was sourced from analyses performed on CRP components packed in financial years 2000/01, 2008/09, 2009/10 and 2010/11 (summarised at Appendix A)[6]. Most of this data has only been reported through internal mechanisms and has not previously been available in the public domain. The analyses conducted on 2008/09, 2009/10 and 2010/11 CR components was limited to approximately 25 components in each year, therefore data from these years is incomplete. Although full nutrient analysis of CRP, for example CR1M, has been conducted on occasions, much of that data is now out-of-date due to changes in components and technologies (see section 1.1 above). From the available data it was necessary to extract the most relevant data to current menus and components. It was also necessary to make some assumptions and decisions about data handling and presentation. The following points arise from these considerations:

- The menu sheet for the 2008/09 packing program was used to create menus for the purpose of this work (Appendix B).
- The baseline nutrient data was the most recent available. The data set was completed as follows:
    - In-house data from the analysis of samples of the 2008/09 and 2009/10 ration packing programs was used wherever available.
    - In-house data from the 2000/01 ration packing program was used where it was considered relevant and suitable.
    - When data for particular components was not available, data for similar components was used instead. In some cases, data provided in Product Information Forms (PIFs) was used in lieu of independent analytical data.

[5] Combat ration components are required to have a warranty period of 24 months when stored at 30 ºC. The warranty period is not consistently expressed in relevant documentation [1, 15, 16]. The warranty conditions are based, at least in part, on time and temperature characteristics of the CRP supply chain.
[6] Most of the pre-post comparisons are based on analyses conducted on a minimum composite of 10 packets/pouches of the component being analysed. Therefore, the variation should be relatively small and packet to packet variation should not be an issue. The analytical issues may include changes in methodology and inter-laboratory variation.

- The main sources of post-storage data were storage trials conducted on CR components from the 2008/09 and 2009/10 ration packing programs. The storage trial was conducted over a period of 24 months with samples held at 30 °C.

- The following assumptions, substitutions and approximations were made:

    - Baseline nutrient data is referred to herein as 'pre-storage' data and is assumed to be equivalent to the nutrient content of CR components at time of assembly.
    - The data collected on samples after storage is referred to herein as 'post-storage' data and is assumed to be equivalent to the nutrient content of CR components at the time of consumption.
    - Data for fruit spread, raspberry (2009/10) was used for all CR1M fruit spread items. It is the only fruit spread that has been recently analysed and the older data (2000/01) appears to be for a fortified product whereas the current product is not fortified.
    - Data for meatballs, beef with sweet and sour sauce (2008/09) was used for all beef and lamb main meals in the absence of data for the following: braised beef and gravy, beef teriyaki, beef mince with spaghetti, beef BBQ and lamb with rosemary.
    - Salmon and pasta mornay (as named in CR1M menu sheets) was assumed to be salmon and pasta with cheese sauce (as named in ADFFS).
    - Data for savoury soup (2008/09) and beef soup, low salt (2008/09) were used for tomato soup and chicken soup, respectively.
    - Data for sports beverage powder (3 different flavours: lemon lime, grape and orange) (2010/11) were used for beverage powder, type II.
    - Protein contents for the following components were extracted or calculated from PIFs: braised beef and gravy, beef teriyaki, chicken curry, beef BBQ, chicken italiano, beef mince with tortellini, chilli con carne, beef mince with spaghetti, lamb with rosemary, and soup powders (chicken and tomato flavoured).

- The food components have been formed into five main groups[7] to facilitate data analysis and discussion:

    - Main meal (retort meals, baked beans, tuna);
    - Cereal (biscuits, muesli bars, muesli mix, noodles (including flavouring), freeze dried rice);
    - High fat confectionery (ration chocolate, chocolate candy, confectionery spreads);
    - Low fat confectionery (spreads, fruit grains);

[7] Dry and wet condiments have not been included in the analysis since overall contribution to the vitamin and mineral content of the CR1M is negligible.

- Dairy (condensed milk, cheddar cheese, skim milk).

- Degradation of nutrients during storage was calculated as the differences between the pre- and post-storage values.
- As CR1M menus are changed and new data becomes available, the nutrient composition of the CR1M is likely to differ from that presented in this report.

The nutrient content for each of the eight menus (A–H) of CR1M were summarised and assessed against the nutritional criteria prepared by Forbes-Ewan [4]. Pre-storage nutrient content (representing the condition at time of receipt by Defence) was assessed against the Recommended Nutritional Criteria[8] (RNC) for general purpose ration packs. Post-storage nutrient content (approximating the condition at time of consumption) was assessed against the Military Recommended Dietary Intakes (MRDI). Protein intakes were assessed against the Category 3 physical workload requirements for adult males. Micronutrients were assessed against the requirements of each sub-group (adolescent male, adolescent female, adult male and adult female) with the greatest need at Category 3 physical workload [4]. Table 1 details the nutrients investigated, the RNC and MRDI reference values and the sub-groups.

Table 1: Nutrients, RNC, MRDI and sub-groups studied in this report

Nutrient	RNC	MRDI	Sub-group
Protein (g)	122-150	122-169	Adult males
Thiamin (mg)	5.1	1.7	Adolescent males
Riboflavin (mg)	7.5	2.5	Adolescent males
Niacin (mg)	78	26	Adult/adolescent males
Folate (μg)	400	400	All
Vitamin B6 (mg)	7.5	2.5	Adolescent males
Vitamin B12 (μg)	2.4	2.4	All
Vitamin C (mg)	135	45	Adult males and females
Vitamin A (μg)	900	900	Adult/adolescent males
Vitamin D (μg)	5	5	All
Vitamin E (mg)	10	10	Adult/adolescent males
Vitamin K (μg)	70	70	Adult males
Iron (mg)	18	18	Adult females
Calcium (mg)	1300	1300	Adolescent males and females

It is important to note that the assessment against the MRDI assumes consumption of the entire ration pack. As previously stated, under-consumption is a known problem,

[8] The RNC levels of vitamin C, thiamin, riboflavin, niacin and vitamin B6 are three times the MRDI for the sub-group with greatest estimated requirement for that nutrient at Category 3 physical workload. This allows for likely nutrient loss during storage and for the discarding of CR items [4].

therefore actual intakes will on average be lower and the assessment against the MRDI represents a best-case scenario.

2. Levels of Key Nutrients in CRP

2.1 Protein vs RNC

The following discussion relating to protein content focuses on whether the minimum RNC for protein is met. The analytical data shows protein is well distributed across the items within daily menus (Figure 1). The pre-storage values range from 75–136 g, which is 61–111% of the RNC. Main meal, dairy and cereal items are the major contributors of protein, providing 15–71%, 14-15% and 9–17%, respectively. Menu A is the only menu that meets the minimum RNC for protein.

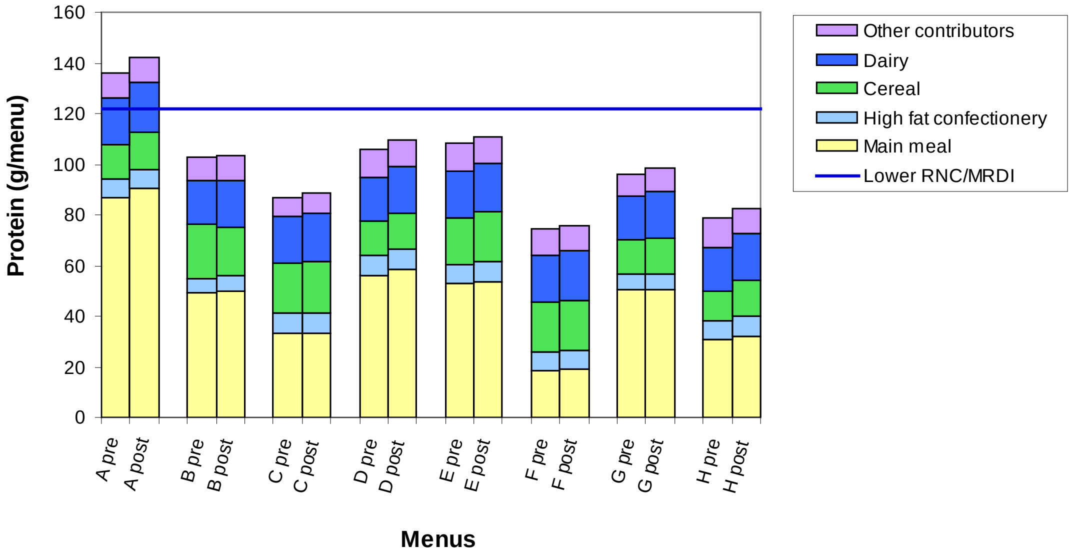


Figure 1: Major contributors of protein: pre- and post-storage data vs lower RNC/MRDI.

2.2 Protein vs MRDI

As demonstrated in Figure 1, there are only minor differences between the pre- and post-storage protein levels. Since protein is a macronutrient, losses are not anticipated as a result of extended storage at 30 °C. Post-storage data ranges from 76–142 g per menu, which is 62–116% of the MRDI for the minimum requirement of protein. The main contributors of protein – the main meal, dairy and cereal items - provide 16–74%, 15-16% and 12–16%, respectively. Menu A is the only menu that meets the minimum MRDI for protein. Our data indicates a slight increase in the protein content across the menus post storage; this is accepted as being within the overall error associated with these analyses.

2.3 Thiamin vs RNC

The pre-storage contribution of thiamin ranges from 5.7–7.3 mg, equivalent to 1.1–1.4 times the RNC (Figure 2). There are three main sources of thiamin in the CR1M: main meal (34–64%), high fat confectionery (27%) and vegetable extract (43%).

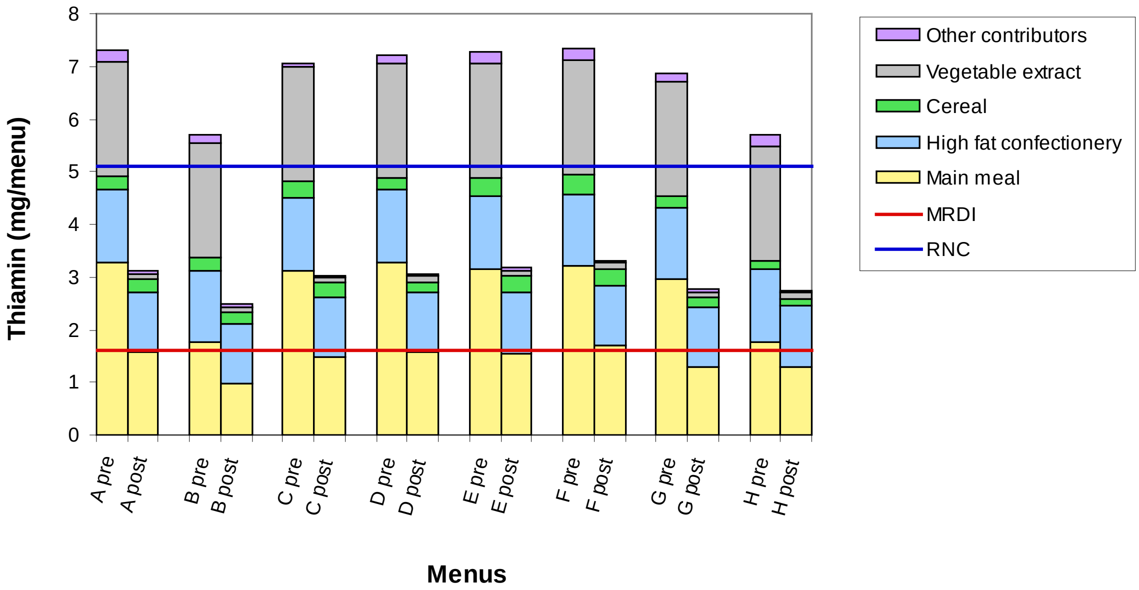


Figure 2: Major contributors of thiamin: pre- and post-storage data vs RNC and MRDI.

2.4 Thiamin vs MRDI

Thiamin is heat labile [15], therefore some degradation is expected during extended storage at 30 °C. The post-storage contribution of thiamin ranges from 2.5–3.3 mg, equivalent to 1.5–1.9 times the MRDI (Figure 2). The level of degradation ranges from 26–36% in main meals, 18% in high fat confectionery, 95% in vegetable extract and 4-15% in cereals.

The post-storage data indicates that the main meal and high fat confectionery food groups provide 57–100% and 66–67% of the MRDI, respectively. Although there is a significant drop in the amount of thiamin provided by the vegetable extract, the combination of the thiamin content of the main meal and high fat confectionery items provides 1.2–1.7 times the MRDI across the CR1M menus (see Figure 2).

2.5 Riboflavin vs RNC

The pre-storage contribution of riboflavin ranges from 3.4–8.8 mg, equivalent to 0.5–1.2 times the RNC (Figure 3). Vegetable extract (28%) and main meal items (2–74%) are the major contributors of riboflavin to the CR1M. The main meal items are the greatest contributors of riboflavin for all menus, except menu H. Menus B and H do not meet the

RNC for riboflavin, providing 79% and 46%, respectively. This is due to the inclusion of main meals containing relatively low levels of riboflavin in these menus.

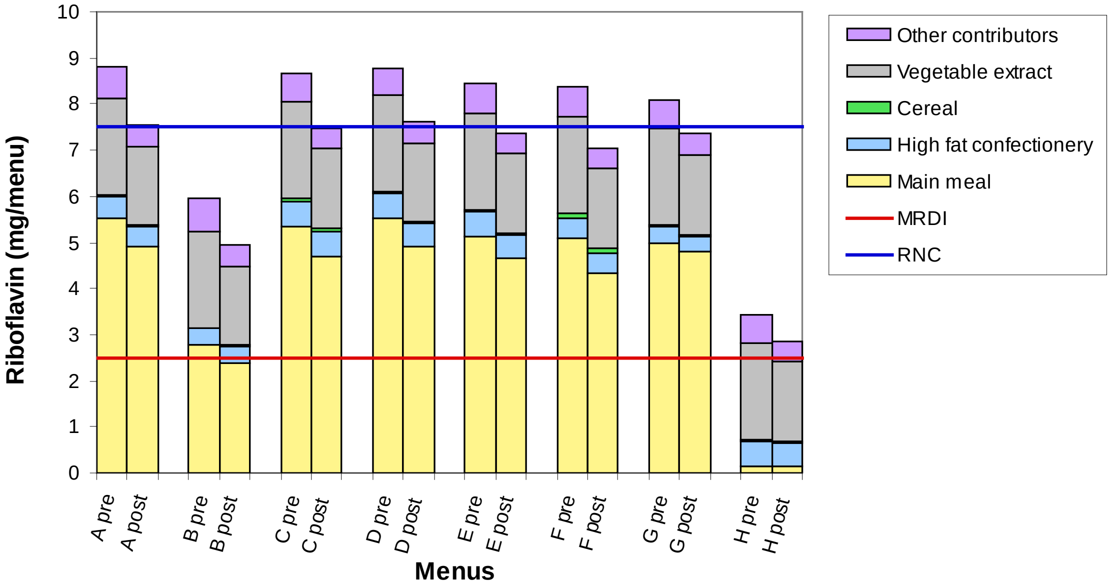


Figure 3: Major contributors to riboflavin: pre- and post-storage data vs RNC and MRDI.

2.6 Riboflavin vs MRDI

The post-storage contribution of riboflavin ranges from 2.9–7.6 mg (Figure 3). Riboflavin is generally considered to be stable during thermal processing, storage and food preparation [16]. However, our data reveals degradation during storage ranging from 4–15% for main meal, 18% for vegetable extract, 2–5% for high fat confectionery and 6–44% for cereal items. As Figure 3 demonstrates, the overall effect is very little decrease in riboflavin content as a result of storage with menus providing 1.2–3.0 times the MRDI.

2.7 Niacin vs RNC

The pre-storage contribution of niacin ranges from 59–104 mg, equivalent to 0.8–1.3 times the RNC (Figure 4). The main meal group is the major contributor (43–98%), followed by vegetable extract (17%) and high fat confectionery (11–15%). Menu B provides 76% of the RNC, whereas menus F and H marginally reach the RNC at 93% and 98%, respectively. The other menus exceed the RNC.

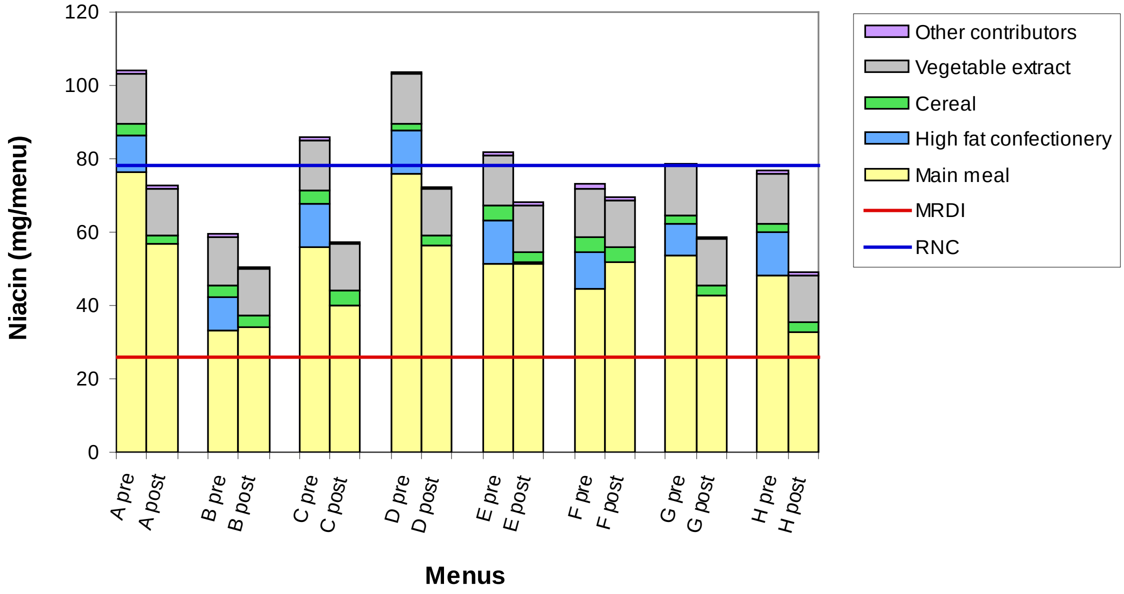


Figure 4: Major contributors of niacin: pre- and post-storage data vs RNC and MRDI.

2.8 Niacin vs MRDI

The post-storage contribution of niacin ranges from 49–90 mg which is equivalent to 1.9–3.5 times the MRDI. Niacin is recognised as one of the more stable vitamins in food [17]. However, the post-storage data demonstrates a complete degradation of niacin in high fat confectionery, while other losses were from the main meal (up to 32%), cereal (up to 30%)[9] and vegetable extract (6%) items (Figure 4). Although the post-storage data demonstrates up to 32% loss of niacin from the main meal items, the niacin levels in this food group are still relatively high.

2.9 Folate vs RNC

The pre-storage contribution of folate ranges from 174–302 µg, equivalent to 43–76% of the RNC (Figure 5). The analytical data indicates a greater than 50% deficit in menus C and G. Cereal, main meal and canned fruit items are the main sources of folate, providing 17–23%, 12–41% and 5–10%, respectively, of the RNC (Figure 5).

[9] Niacin levels in cereal items were relatively low and the data was subject to the influence of a few anomalous data points. Losses were up to 30% but gains were of a similar order, up to 27%.

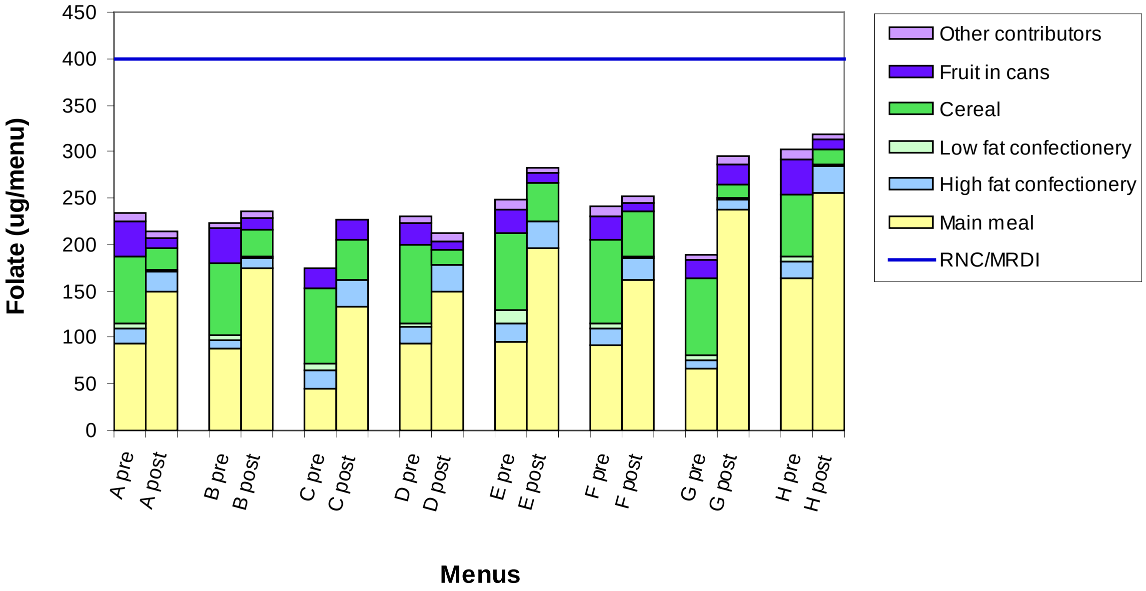


Figure 5: Major contributors of folate: pre- and post-storage data vs RNC/MRDI.

2.10 Folate vs MRDI

The post-storage contribution of folate ranges from 212–319 µg, equivalent to 53–80% of the MRDI (Figure 5). The results indicate a 40–47% deficit in menus A, B, C and D. Losses of folate were 60–70% (canned fruit), 46–82% (cereal) and 55–100% (low fat confectionery). These are similar to the results of other investigations indicating that folate is highly susceptible to degradation as a result of heat treatment and storage [16]. In contrast, there were apparent increases in folate levels in high fat confectionery (27–57%) and the main meal items (56–252%) when compared to the pre-storage levels. This is discussed in section 3.1.5 below.

2.11 Vitamin B6 vs RNC

The pre-storage contribution of vitamin B6 ranges from 0.3–0.8 mg, which is 4–11% of the RNC. Vitamin B6 is present in a few CR1M menu items (main meal, soup, confectionery cream spread, ration chocolate, chocolate candy and vegetable extract) at very low concentrations. In the remaining items vitamin B6 is even lower, being close to or below the detection limit.

The main meal group provides 1.3–4.0%, high fat confectionery 1.2–1.6% and soup 0.4–5.6% of the RNC. The pre-storage data indicates insufficient amounts of this nutrient with a shortfall of 89–96% of the RNC across the CR1M menus (Figure 6).

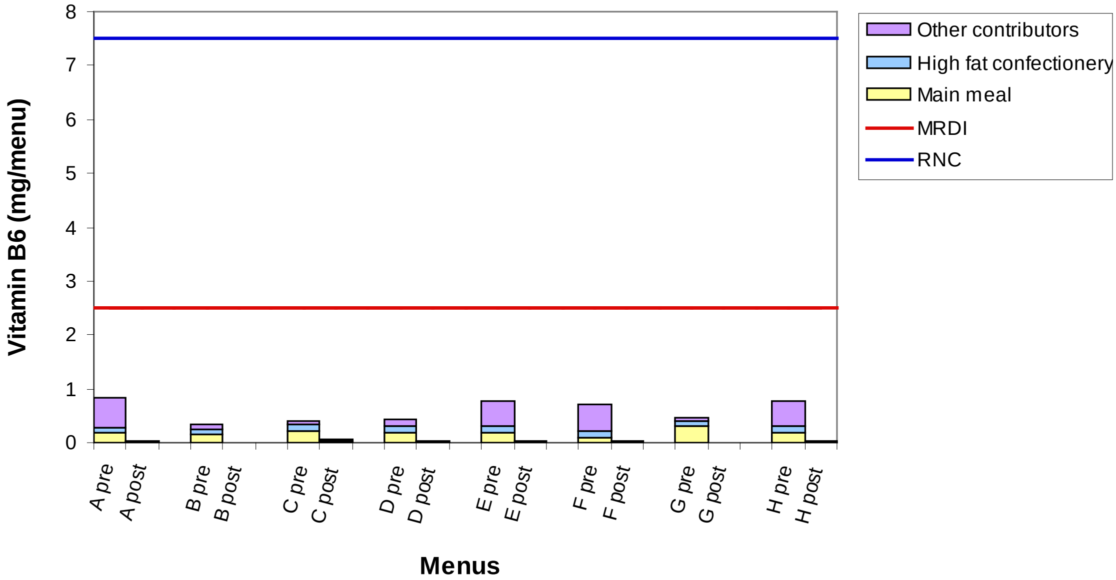


Figure 6: Major contributors of vitamin B6: pre- and post-storage data vs RNC and MRDI.

2.12 Vitamin B6 vs MRDI

The post-storage contribution of vitamin B6 ranges from 0.02–0.05 mg, equivalent to 0.6–2.0% of the MRDI. The initial low levels of vitamin B6 decreased further as a result of storage; no vitamin B6 was retained in the main meal. There was 62% degradation in ration chocolate and up to 100% in confectionery cream spread. In all other items vitamin B6 levels were below the detection limit. This data indicates a shortfall across the CR1M menus of approximately 99% of the MRDI (Figure 6).

2.13 Vitamin B12 vs RNC

The tuna items provide a high proportion of the total vitamin B12 content in the CR1M menus. In order to display the differences within the main meal items, the data for tuna items has been plotted separately from the other items belonging to the main meal group. The pre-storage data indicates that total vitamin B12 content of all menus is in excess of the RNC, ranging from 3.0–8.1 µg (Figure 7). Thus, a surplus of vitamin B12 in the CR1M for all menus is evident, ranging from 1.3–3.4 times the RNC. The main sources of vitamin B12 are dairy, main meal and tuna items (60%, 56–271% and 133% of the RNC, respectively).

Beef mince with tortellini data was used due to the unavailability of data for both the main meals in Menu G (chilli con carne and beef mince with spaghetti). The data from this substitution enhanced the total vitamin B12 in menu G substantially (2.7 times the RNC). The vegetable based main meal items included in menu H do not provide any vitamin B12.

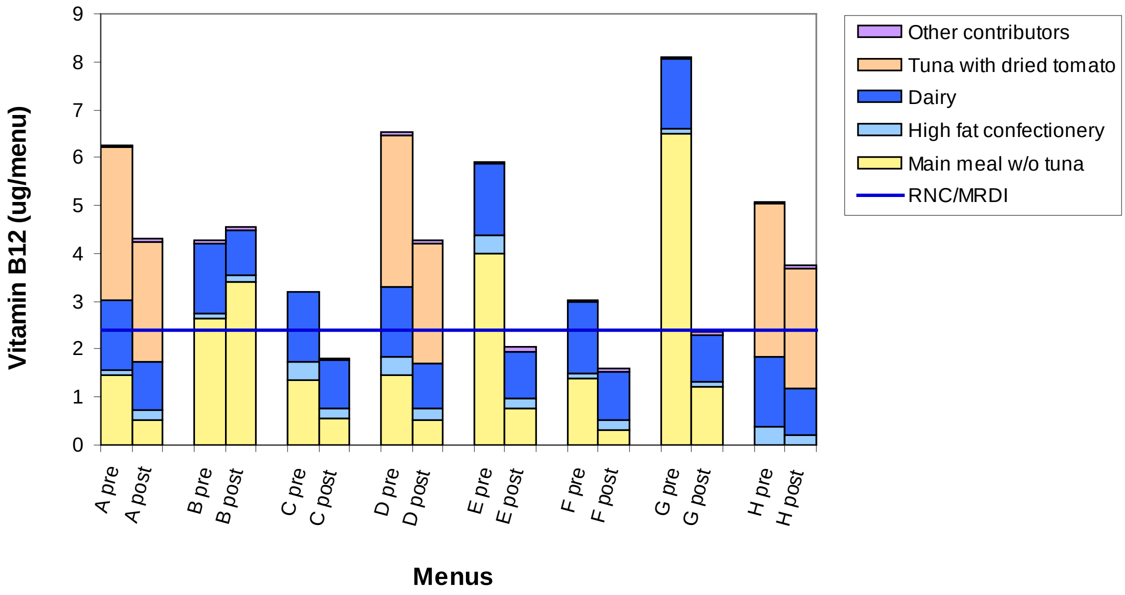


Figure 7: Major contributors of vitamin B12: pre- and post-storage data vs RNC/MRDI.

2.14 Vitamin B12 vs MRDI

The post-storage data of vitamin B12 ranges from 1.6–4.6 µg, equivalent to 76–190% of the MRDI (Figure 7). Degradation during storage ranges from 26–71% across the CR1M menus with 59–85% in the main meal items (including 21% of tuna); and 43% in high fat confectionery. High losses were observed in menus E and G (66% and 71%, respectively).

Conversely, there was 71% increase, relative to the pre-storage value, in vitamin B12 in the menu B main meal item—salmon and pasta mornay. The discussion in section 3.1.5 on increases in folate levels post-storage may be relevant as both folate and vitamin B12 were determined by bioassay. If the degradation of vitamin B12 observed in the main meal items (not including tuna) from menus C, E, F and G were to be applied to menu B, the levels would be marginal.

There is a surplus of vitamin B12 in menus A, D and H which contribute 1.8, 1.8 and 1.6 times the MRDI, respectively, whilst menu G is equal to the MRDI. Menus C, E and F contribute poorly at 0.76, 0.85 and 0.67 times the MRDI, respectively. Without the contribution from tuna, menus A, D and H would contain insufficient amounts of vitamin B12.

2.15 Vitamin C vs RNC

The pre-storage data for vitamin C ranges from 464–778 mg, equivalent to 3.4–5.8 times the RNC. The major contributors of vitamin C in the CR1M are the main meal items (1.7–4.1 times the RNC) and the sports beverage powders (1.4–1.6 times the RNC) (Figure 8).

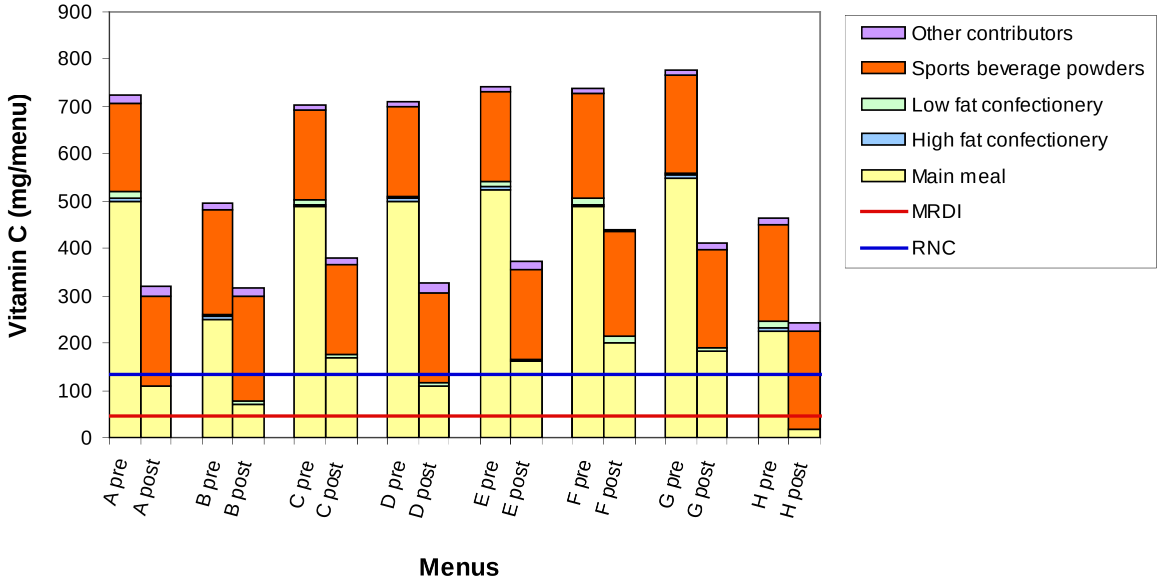


Figure 8: Major contributors of vitamin C: pre- and post-storage data vs RNC and MRDI.

2.16 Vitamin C vs MRDI

The post-storage levels for vitamin C range from 241–438 mg per menu (Figure 8). The two main sources are the main meal and sports beverage powder items. The latter is stable when stored for up to 12 months at 40 °C. Despite the substantial reduction of vitamin C in the main meal items (59–92%) during storage, the residual levels of vitamin C are still 5.4–9.7 times the MRDI.

2.17 Vitamin A vs RNC

The pre-storage data for vitamin A ranges from 824–972 µg per menu, equivalent to 92–108% of the RNC (Figure 9). Vitamin A levels were found to be below the detection limit for most CR1M items, except the main meal, high fat confectionery, cheddar cheese, scotch finger biscuit and sweetened condensed milk (Figure 9).

High fat confectionery is the major contributor of vitamin A to CR1M menus, providing 62% of the RNC. Ration chocolate alone contributes 60% of the RNC. Other significant sources of vitamin A are the cheddar cheese, scotch finger biscuit and salmon and pasta mornay, providing 18%, 13% and 12% of the RNC, respectively. All other main meal items provide approximately 1.3–12.1% of the RNC. The pre-storage data indicates sufficient vitamin A in menus B, F and G, but there are shortfalls of 5–8% in all other menus.

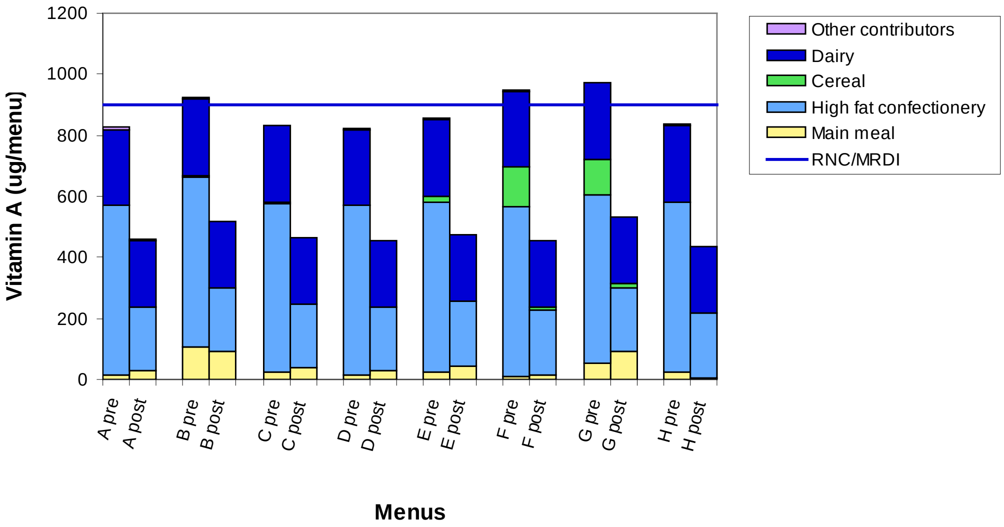


Figure 9: Major contributors to vitamin A: pre- and post-storage data vs RNC/MRDI.

2.18 Vitamin A vs MRDI

The post-storage data for vitamin A ranges from 435–531 µg, which is equivalent to 48–59% of the MRDI (Figure 9). There is a loss of 64% of vitamin A in ration chocolate during storage. On the other hand, there was a substantial increase in the amount of vitamin A in the main meal items, ranging from 33–84%, in menus A, C, D, E, F and G. The apparent increase is likely to be indicative of limitations of the analysis of either the pre- or post-storage samples—especially at low levels—and not necessarily a true indication of an increase in the concentration of vitamin A in the main meal items. Losses of vitamin A from main meal items in menus B (17% loss) and menu H (80% loss), were observed. The main meal items in menu H provide less than 1% of the MRDI.

Ration chocolate continues to be the major contributor of vitamin A, providing approximately 22% of the MRDI. Figure 9 demonstrates a shortfall of vitamin A in all menus after storage.

2.19 Vitamin E vs RNC

The pre-storage data for vitamin E ranges from 9–21 mg per menu, equivalent to 0.8–2.1 times the RNC (Figure 10). The data demonstrate that vitamin E exceeds the RNC in most CR1M menus, except menus B and G (15% and 6% below the RNC, respectively).

High fat confectionery (especially the confectionery spread items), main meals, cereals and canned fruit are the major contributors of vitamin E, providing approximately 9–94%, 6–54%, 20–41% and 10–22% of the RNC, respectively.

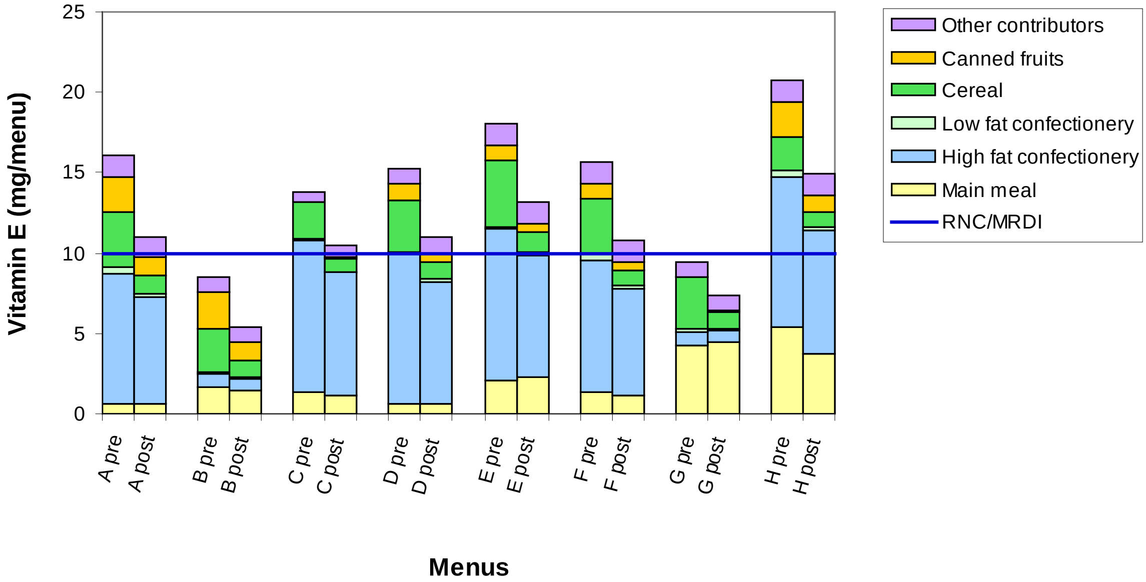


Figure 10: Major contributors of vitamin E: pre- and post-storage data vs RNC/MRDI.

2.20 Vitamin E vs MRDI

The post-storage data for vitamin E ranges from 5–15 mg, equivalent to 0.5–1.5 times the MRDI (Figure 10). The data indicates vitamin E content in most of the menus meets the MRDI. The exceptions—menus B and G—contribute 53% and 74%, respectively of the MRDI and are the only menus not to contain the confectionery spread.

Losses of vitamin E after 2 years storage at 30 °C were up to 17% in high fat confectionery, 11% in canned fruits and 16% in main meals. The confectionery spread analysed for this study contained 2–6% hazelnut which explains the large contribution of vitamin E from this component.

2.21 Vitamin K vs RNC

The pre-storage data for vitamin K ranges from 22–43 µg per menu, which is 32–62% of the RNC (Figure 11). Major sources of vitamin K are the main meal items, high fat confectionery and cereals (10–27%, 7–18% and 7–12% of the RNC respectively). The data indicates that all CR1M menus contain levels of vitamin K that are well below the RNC (Figure 11). Although vitamin K is present in small amounts, it is well distributed across items within the CR1M menus. Menus B and G provide the least amount of vitamin K, partly due to the absence of the confectionery spreads, at 32% and 36% of the RNC, respectively.

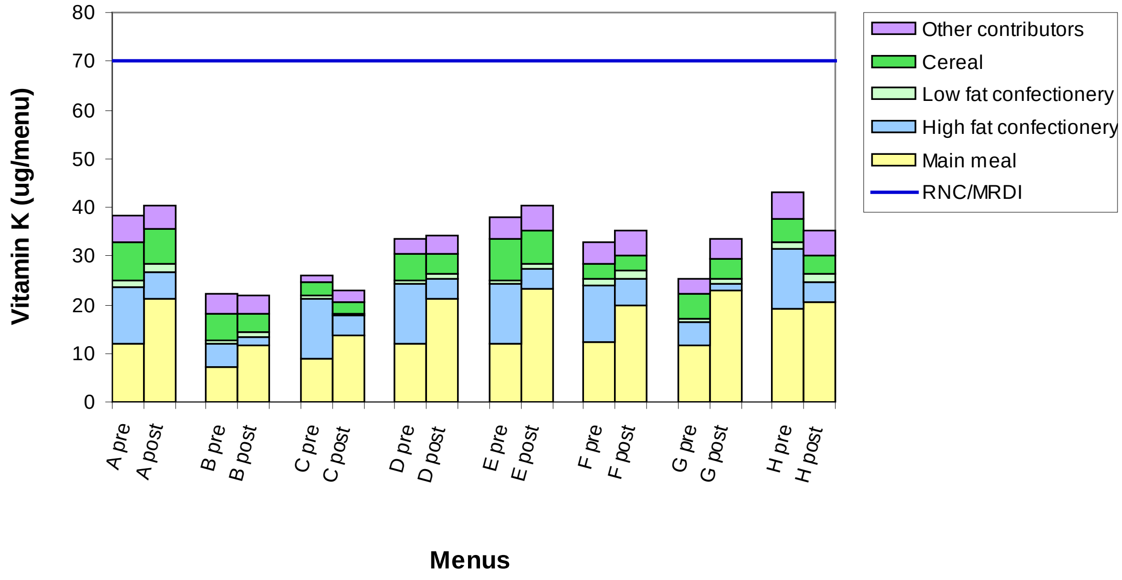


Figure 11: Major contributors of vitamin K: pre- and post-storage data vs RNC/MRDI.

2.22 Vitamin K vs MRDI

The post-storage data for vitamin K ranges from 22–40 µg, which is 31–58% of the MRDI. There was a 52%–68% degradation of vitamin K in the high fat confectionery. In contrast, a 2–16% increase in vitamin K was observed in most of the main meal items, but this is most likely within the measurement uncertainty for this vitamin.

2.23 Iron vs RNC

The pre-storage data for iron ranges from 14–17 mg per menu, which is 77–96% of the RNC (Figure 12). The analytical data shows iron is well distributed across items in CR1M menus. Major contributors of iron are the main meal items (13–39%), cereal items (17–33%), high fat confectionery (14–19%) and chocolate beverage powder (13%).

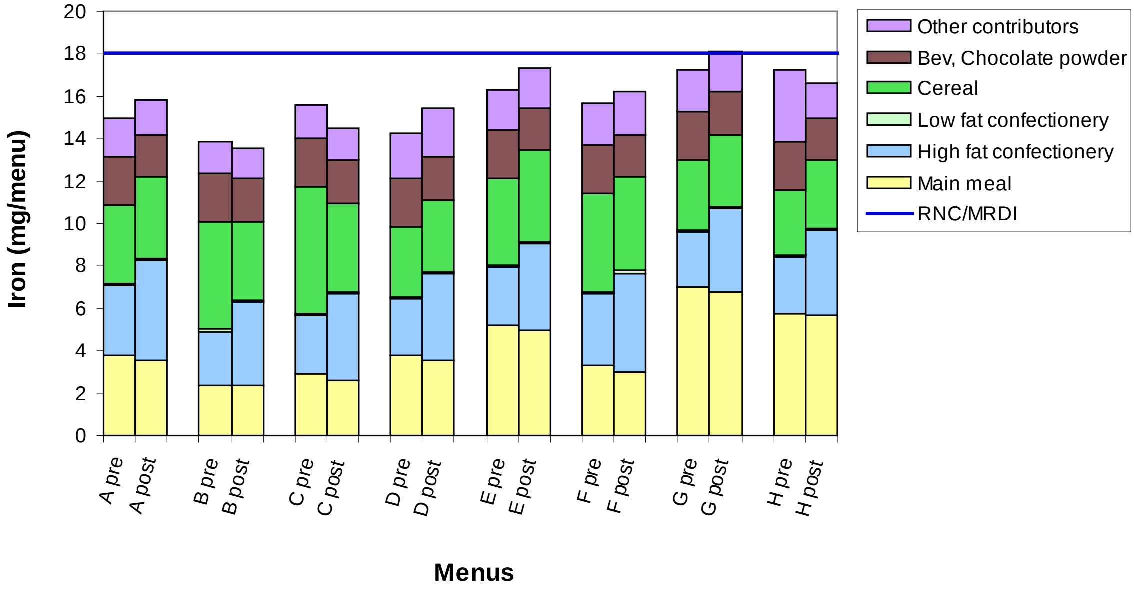


Figure 12: Major contributors of iron: pre- and post-storage data vs RNC/MRDI.

2.24 Iron vs MRDI

The post-storage data for iron ranges from 14–18 mg, which is equivalent to 81–101% of the MRDI (Figure 12). The data demonstrates that iron, as expected, is quite stable during storage. Since iron is a metallic element it is not considered labile and will not be denatured in response to CRP storage conditions. An 8% increase in the level of iron in high fat confectionery products was observed, but this is accepted as being within the overall error associated with these analyses.

2.25 Calcium vs RNC

The pre-storage levels for calcium range from 1050–1167 mg per menu, equal to 81–90% of the RNC (Figure 13). Calcium is well distributed across the range of menus. Major contributors are dairy (47%), high fat confectionery (13–18%), main meal items (6–12%), and cereal items (3–5% of the RNC).

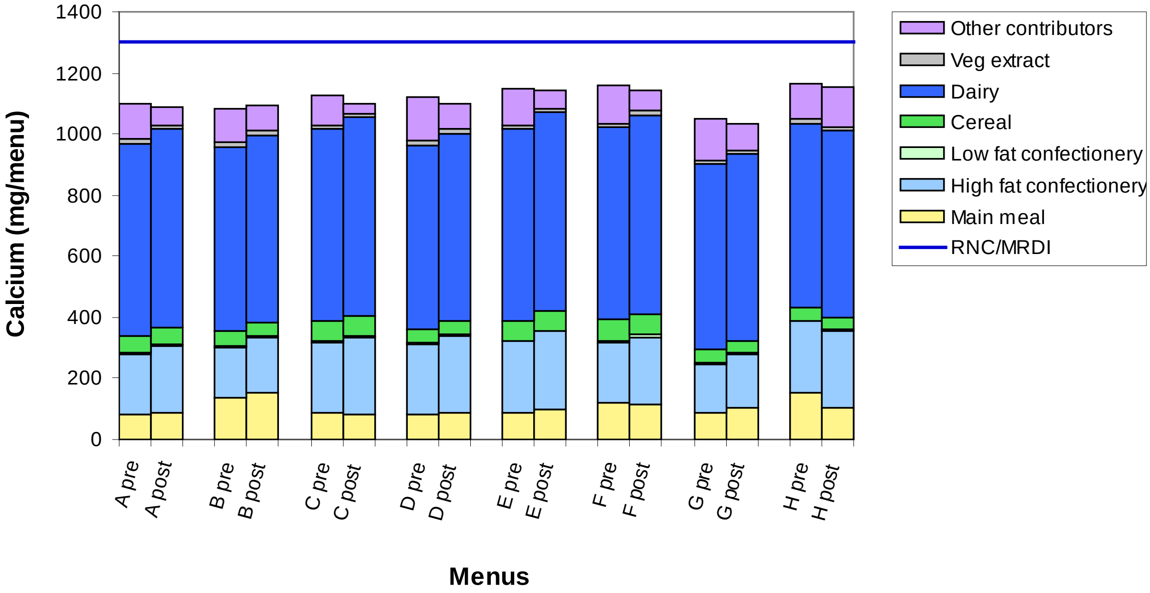


Figure 13: Major contributors of calcium: pre- and post-storage data vs RNC/MRDI.

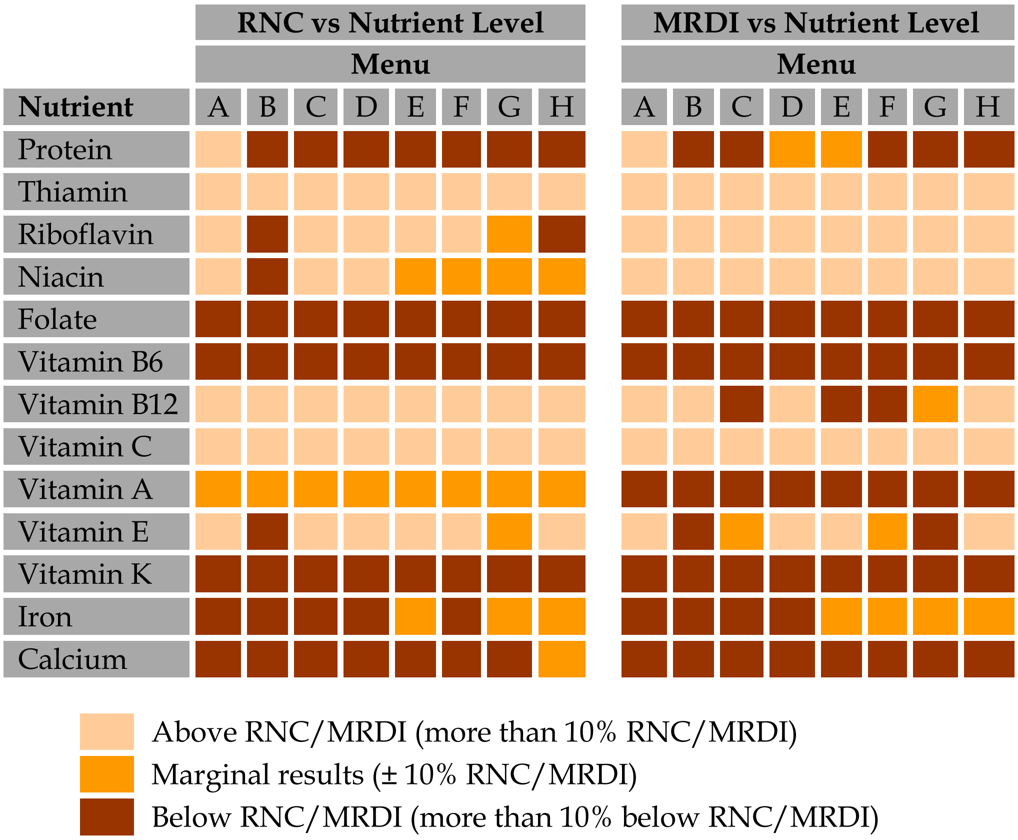
2.26 Calcium vs MRDI

The post-storage calcium levels range from 1100–1152 mg per menu, which is equal to 80–88% of the MRDI (Figure 13). The slight variations between pre- and post-storage data are interpreted as analytical variation. Overall, calcium is stable during storage.

2.27 Summary of Nutrient Levels in CRP

Table 2 provides a summary of the nutrient levels per menu of the CR1M pre- and post-storage. Nutrients of concern are identified and are discussed in the remainder of this report.

Table 2: Status of CRP nutrients relative to RNC and MRDI requirements.



3. Nutrients of Concern

The results from this study indicate that CRP is failing to meet some nutritional requirements when assessed against RNC and MRDI. The combination of various low levels of some nutrients in CRP, under consumption and the amount of time troops spend rationed solely or predominately on CRP, contributes to an increased risk that troops will be inadequately nourished.

The following section provides greater detail on each individual nutrient that was investigated and the areas of concern that need to be addressed.

3.1 Protein

The protein content across menus is disparate, mainly due to the composition of the main meals. Menus that contain meals high in protein, such as BBQ chicken and braised beef and gravy, also contain tuna, resulting in high protein contents. Menus containing main meal items low in protein, for example sausages and vegetables and beef meatballs with sweet and sour sauce, are not compensated by other high protein products, resulting in very low overall protein content.

The research has found the meat content of some meat based, retort meals to be substantially less than the specified requirements. If the main meal components were made to specification the protein content of CRP would improve.

3.2 Thiamin

Although the data indicates that thiamin levels are adequate in CR1M at the time of consumption, the supply of thiamin is reliant on the consumption of three groups of components: the main meal items, high fat confectionery and the vegetable extract. The main meals and high fat confectionery are generally consumed by the majority of CR1M users, therefore thiamin requirements are likely to be met. Vegetable extract has been found to be poorly consumed and highly discarded by consumers [18], thus reducing the options for thiamin intake.

3.3 Riboflavin

Riboflavin levels in CR1M menus are adequate at the time of consumption, therefore the total levels are not of concern. However, significant sources of riboflavin are limited to only three groups of components: main meal items, high fat confectionery and the vegetable extract. Vegetable extract is a highly discarded item, whilst the high fat confectionery and main meals are highly consumed items [18]. Reliance on riboflavin being obtained from only three components, one of which is highly discarded, risks under-consumption of this vitamin by ADF members.

The RNC for riboflavin may need to be revised since our results indicate very little loss of this nutrient as a result of storage. The RNC is currently set at 3 times the MRDI, but this may not be necessary. It is suggested that slightly above the MRDI would be an appropriate value to use as the RNC for riboflavin.

3.4 Niacin

It is likely that ADF members will meet their nutritional requirements for niacin when CRP is the sole source of nutrition, provided the main meal items are consumed at reported levels [18]. Achieving the recommended niacin intake is dependant on the consumption of the main meal items. Animal proteins are a good source of both preformed niacin and the amino acid tryptophan. The latter can be converted to niacin and thereby contribute to total niacin intake [14]. However, if there is inadequate intake of iron, riboflavin or vitamin B6 the conversion of tryptophan to niacin is decreased [19]. Therefore it is essential that sufficient amounts of these vitamins are available in CRP.

3.5 Folate

Folate is unstable when exposed to heat and common storage conditions. We can therefore confidently assume that folate levels will reduce during storage at 30 °C. The apparent increase in folate levels, as indicated by our results in section 2.8, may be due to the bioassay method that was used to analyse the samples. This method can be subject to significant variation and operator dependency. In addition, it has been suggested that storage conditions and different methods of sample preparation may increase the availability of free folate for the assay microorganism [16]. It is recommended that the potential for an apparent increase in folate levels in certain CR components be investigated. Despite some uncertainty over the accuracy of the results, there is sufficient information to conclude that the folate content of CR1M is significantly below recommended levels both pre- and post-storage.

Folate intakes in the general population are also significantly below dietary recommendations [14]. Due to the protective affect that folate provides against serious birth defects, the mandatory fortification of wheat flour for bread-making was introduced in Australia in 2009 [20]. In addition, there is increasing evidence that folate may also play an important role in the reduction of chronic diseases such as cardiovascular disease and cancer [14, 21]. Therefore, there is a need to improve the delivery of this nutrient to soldiers when they are being fed with CRP.

3.6 Vitamin B6

Vitamin B6 is unstable and is denatured during processing and extended storage at high temperatures [16, 17]. Loss of vitamin B6 was observed in the CR1M items analysed in this study. Post-storage data indicates almost 100% loss of vitamin B6 from the major contributors in the CR1M menus. There was no substantial contribution of vitamin B6 either pre- or post-storage from any of the components analysed.

3.7 Vitamin B12

The supply of vitamin B12 in the CR1M is reliant on the consumption of three types of components: the main meal, dairy and tuna items. These groups have been found to be highly consumed. Tuna items are not provided with all of the CR1M menus. Two of the four menus without tuna do not provide the MRDI for vitamin B12 after storage for 2 years at 30 °C, whilst menu G is marginal.

Due to the storage of vitamin B12 in the liver and evidence that the majority of the menus provide adequate amounts of vitamin B12, it is unlikely that soldiers will become deficient in this nutrient. However, if we are to consider the 'worst case' scenario for troops on long term rationing with CRP, other means of supplying vitamin B12 must be considered, particularly for menus C, E and F that do not meet the MRDI for vitamin B12.

3.8 Vitamin C

The availability of vitamin C in the CR1M after storage for 2 years at 30 °C is in excess of the MRDI for all menus due to the contribution from the main meal items and the sports beverage powder. The results indicate that the main meal items, except for those included in menu H, provide the MRDI for vitamin C.

However, the intake of adequate vitamin C is dependent on the consumption of only two components. The main meals in the CR1M generally have a high acceptability and consumption rate, but the sports beverage powders, also rated highly for acceptability, have a history of poor consumption. An in-house study conducted in 2006, investigating a prototype light weight ration found all flavours of the CR1M sports beverage powder (used in the prototype ration) were either 'liked' or 'loved' by 67% of respondents, however 44-63% of respondents did not consume the entire product. A later DSTO study comparing the CR1M with a prototype hot weather ration conducted in 2008, also found that less than 50% of the CR1M sports beverage powders were consumed, even though the product rated highly for acceptability [18].

The hot weather ration study also investigated the acceptability and consumption of a COTS sports beverage powder packaged in a zip lock bag that could be used for the preparation and consumption of the sports beverage powder. All flavours of the COTS sports beverage powder received slightly higher mean acceptability ratings and much greater rates of consumption compared to the CR1M product. The authors suggested that the overall organoleptic acceptability of this product and the novel packaging may have contributed to the greater consumption rates [18]. To improve the consumption of the current CR1M sports beverage powders it is recommended that the packaging used in the hot weather trial be considered for use in the CR1M.

3.9 Vitamin A

Vitamin A is widely distributed throughout the CR1M menus. However, vitamin A levels in the CR1M are suboptimal and need to be improved. High fat confectionery is the major contributor of vitamin A, providing more than 60% of the RNC. Ration chocolate has high consumption rates with 78% of survey respondents to an in-house DSTO survey, conducted in 2002, indicating they ate 'some' or 'all' the ration chocolate. A similar study conducted in 2008 found that 72% of respondents consumed the ration chocolate [18]. However, ration chocolate often develops blooming during storage. In some cases, blooming is extreme and is accompanied by a complete physical breakdown of the chocolate. This leads to consumer rejection of the product due to poor sensory qualities. For these reasons, additional good quality sources of vitamin A are required in CRP menus.

3.10 Vitamin D

The major source of vitamin D for humans is from formation in the skin as a result of sunlight exposure. If sunlight exposure is adequate there is little or no requirement for vitamin D to be supplied from the diet [14, 22, 23]. Populations that wear protective clothing and always use sunscreen may be at increased risk of deficiency [14, 22-26]. Due to current eating patterns and food supply it is almost impossible for the general population to consume sufficient vitamin D [14]. There is increasing evidence that a significant number of Australians have sub-optimal levels of vitamin D, however data is limited [22-24, 26]. A number of studies conducted on the vitamin D status of Australians concluded that a wider range of foods should be considered for fortification with vitamin D, or that supplementation should be used to ameliorate insufficient intakes and deficient vitamin D status in the Australian population [22-24, 26].

Soldiers are often well-covered in military uniform, limiting sunlight exposure and the production of vitamin D. If the military population has similar vitamin D status as the general Australian population, troops may commence operations or field exercises with a reduced vitamin D status, putting them at risk of deficiency and the associated complications.

Marginal calcium intakes may lead to increased vitamin D requirements due to the role of vitamin D in releasing calcium from bone stores when dietary calcium is below requirements [14]. Calcium is inadequately provided by CRP, therefore the requirement for dietary vitamin D may increase for soldiers rationed with CRP. The Institute of Medicine has recommended that the short-term assault ration, used by the US military, should contain 12.5–15 μg of vitamin D [25], a figure significantly greater than the amount recommended for Australian CRP (5 μg) [4].

The vitamin D content of CRP should be assessed as levels are unknown. In addition, a review of the RNC and MRDI for vitamin D may be required.

3.11 Vitamin E

At the time of this analysis, all menus of CR1M provided just adequate or less than the MRDI for vitamin E. Since then, the status has been exacerbated by efforts to ensure that CRs are nut-free, since nuts are a good source of vitamin E. In the 2012/2013 procurement of CR1M, a nut-free confectionery spread replaced the hazelnut-containing confectionery spread. This will result in a deficit of vitamin E in all menus of the CR1M when assessed against the RNC and MRDI.

3.12 Vitamin K

Pre-storage vitamin K levels in the CR1M do not meet the RNC and the post-storage content of 15–30 μg is insufficient for ADF members to meet the MRDI. Diet induced deficiencies of vitamin K are rare in free-living individuals [14] and are more likely to be due to a secondary cause such as malabsorption disorders and biliary obstructions [16].

Experimentally induced vitamin K deficiency has been observed in 10 healthy subjects consuming a diet containing less than 10 μg of vitamin K per day [27]. However, more recent studies have observed no clinical signs of vitamin K deficiency in subjects consuming diets containing 5–10 μg of vitamin K per day for a period of 2 weeks [28, 29]. Thus it is unlikely that reliance on CR1M as the sole source of nutrition will lead to subclinical vitamin K deficiency in the short term. However, if CRP were the sole source of nutrition for an extended period, additional vitamin K would need to be provided.

3.13 Iron

The majority of the CR1M menus provide approximately 90% of the RNC for iron: menus A (83%), B (77%) and D (79%) are the exceptions. Although the RNC for iron is not met by any of the menus, this nutrient is well distributed among the components of each of the menus.

Commencing with the 2012/2013 build of the CR1M, a beef snack, similar to beef jerky, is included as a common item in all menus. As a result, an additional 6% of the RNC for iron will be available. With the addition of the beef snack, the RNC for iron in the CR1M menus will range from 83–102%. Menus G and H will provide 102% of the RNC for iron, whilst menus A, C, E and F will be marginally below the RNC (89, 93, 97 and 93%, respectively). Menus B and D will still fail to meet the RNC for iron, providing 83 and 85%, respectively.

Although the inclusion of a beef snack as a common item improves the iron content of CR1M menus, the majority of menus still won't meet the RNC. Iron deficiency is a known problem in Australia and particularly prevalent in females of reproductive age [30]. This problem has also been identified in the Australian military population from a study conducted with female officer cadets, where more than half of the participants were found to be iron deficient [31]. For this reason other options for the supply of this nutrient need to be considered to ensure that sufficient iron is made available to soldiers reliant upon CRP.

3.14 Calcium

Calcium is well distributed throughout the components of the CR1M, however, all menus have been found to provide less than the RNC. ADF personnel working at high levels of physical activity—often in hot climates—have an increased requirement for calcium [32]. DSTO surveys have revealed that 10% of Army recruits (mostly males) [33] and 20% of female officer cadets [34] are at risk of inadequate calcium intakes. For these reasons, additional calcium-containing components and/or the replacement of some components with others containing higher levels of calcium are necessary to improve the overall calcium content of the CR1M menus.

4. Options to improve the nutritional quality of CRP

Historically, the ADF has used fortification as a means to improve the delivery of nutrients to soldiers via CRP. However, the DMO is moving towards a greater dependence on COTS products and only the sport beverage powders, ration chocolate and retort meals will continue to be fortified (F Macasaet [DMO] 2012, pers. comm., 31 August). As a result, there is concern that such CRP based more on COTS components will not be nutritionally adequate to support ADF members.

The next section details a number of options that DMO may consider to ensure that CRP remain as nutritionally adequate as practicable for those troops who consume them. Prior to the adoption of any changes to CRP, the nutrient content of the proposed CRP must be assessed to ensure that soldiers are being provided with the required nutrients. Cost, supply chain and packaging factors have not been considered in detail herein. These would also need to be considered when assessing the feasibility of implementing the options.

4.1 CRP configuration

Aside from the engagement of a prime contractor, the process for the current combat rationing system, comprising procurement, assembly and distribution, has remained virtually unchanged for several decades. The warranty requirement—24 months at 30 °C—limits the number and types of food components that are suitable for inclusion in CRP and the avenues for sourcing them. The vitamin content of food components can also be compromised by the typical storage duration and conditions. Thus there is the potential for the nutritional value of current CRP to be decreased, exacerbating the problems associated with the under-consumption of CRP.

DSTO is investigating elements of the CR supply chain to identify potential efficiency gains and effectiveness of outputs. One element of this is the configuration/design of the current suite of CRP. There are various options currently being investigated, with a particular focus on supply chain and nutritional factors. This may lead to modifications that will lessen or negate the current shelf life warranty requirements for CR components, thereby increasing the range of components that may be suitable for inclusion in CRP. As a result, a greater ability to use COTS products and reduce the costs associated with the production of CRP may evolve.

A re-organisation of existing components across the menus may assist in meeting the RNC. Additional items may be sourced from COTS or military-off-the-shelf (MOTS) products to accommodate any shortfall in particular nutrients. Fortification of existing and new MOTS products may also assist in the delivery of desirable nutrients. This option is similar to what is occurring with the current production of CRP. However, a number of deficiencies in this program exist and need to be addressed. DSTO in-house quality assurance testing of the 2008/2009, 2009/2010 and 2010/2011 CR components found that many of the components tested had at least one non-conformance. It is important that CR components meet specifications and when non-conformances are identified these are rectified without delay.

4.2 Defence-specific component formulation

Defence-specific component formulation may be a very effective means of providing nutritious ration components. These are referred to as MOTS and bespoke items. The approach currently applied in the preparation of the new suite of component specifications is to specify functional and performance criteria for groups of components. In some instances, the best way to meet the criteria may be with MOTS or bespoke items.

A disadvantage of Defence-specific formulations is that they are more expensive than less suitable, but otherwise comparable, COTS items. Nutrients such as protein and carbohydrate could easily be increased in CRP by choosing component ingredients that are naturally high in these nutrients. Nuts, seeds and oils are good examples of ingredients that could dramatically add to the nutritional value of CRP.

4.3 COTS products

In general, there is a move towards greater use of COTS items in CRP. This is due to the inherent advantages of COTS items over MOTS or bespoke items, including low unit cost, low or no cost to Defence for development, ease of procurement, availability, reliability of supply and consumer acceptability. The main potential disadvantage of COTS items is that they may be deficient in terms of nutrient profile, packaging, shelf life and acceptability. The apparent efficiencies associated with COTS items are negated if the functional and performance requirements are not met.

In 2009, an internal Defence report detailing the evaluation of a number of potential COTS products was produced by DSTO for DMO. The recommendations provided in that report have been considered by DMO and in some cases have been or are being implemented. Food products that are specifically produced for active people (e.g. sports formulated products) or people with particular nutritional requirements should be continually evaluated for use in CRP. Awareness of current developments and future directions should be maintained to ensure opportunities are suitably exploited for the benefit of ADF consumers of CRP.

4.4 Fortification

4.4.1 The general community

In Australia and other developed and developing countries of the world, a substantial proportion of the population is at risk of nutrient deficiency. This can have a large impact on the health and economy of a country and is of particular concern for certain sub-groups such as children, women of childbearing age and the elderly [11, 12]. In an effort to reduce the risk of nutrient deficiency, food fortification is the main strategy used in many countries [11, 17]. Food fortification can provide an almost immediate solution, reducing the risk of nutrient deficiency at the population level, whilst maintaining a population's traditional dietary practices [12, 35].

When foods are fortified, there is a slight risk of over-consumption of nutrients by certain sub-groups of the population, particularly those not considered to be at risk of nutrient deficiency. In Australia, this is managed by the government organisation, Foods Standards Australia and New Zealand (FSANZ) in accordance with The Australian New Zealand Food Standards Code (the Code), which details the requirements for foods manufactured and supplied in Australia [36]. According to the FSANZ document 'Regulatory Principles for the Addition of Vitamins and Minerals to Foods' [37]:

> "Vitamins and minerals may be added, subject to no identified risks to public health and safety, at moderate levels (generally 10–25% Recommended Dietary Intake (RDI) per reference quantity) to some foods providing that the vitamin or mineral is present in the nutrient profile, prior to processing, for a marker food in the food group to which the basic food belongs. The vitamin or mineral must be naturally present at a level which would contribute at least 5% of the RDI in a reference quantity of the food. This regulatory principle is based on the restoration or higher fortification of the vitamin or mineral to at least pre-processed levels in order to improve the nutritional content of some commonly consumed basic foods."

Standard 1.3.2 of the Code is the main document that regulates the addition of vitamins and minerals to foods for consumption in Australia. Standards for the addition of vitamin and minerals to specific foods are also available [36]. The related Policy Guideline - Fortification of Food with Vitamins and Minerals [38] defines fortification as "all additions of vitamins and minerals to food including for reasons of equivalence or restoration."

In Australia, the standards within the Code refer to mandatory and voluntary fortification of foods. Mandatory fortification describes the requirement of manufacturers to add certain vitamins and minerals to specific foods. Voluntary fortification, enables manufacturers to choose what permitted vitamins and minerals they wish to add to food. Regulations for the mandatory fortification of food are based on significant public health needs. For example, in Australia, it is mandatory to add vitamin D to margarine and thiamin, folic acid and iodine must be added to bread-making flour [36].

When fortification has been used with the general public, it has been found to be an economically feasible public health initiative [39, 40]. For example, in Australia, the mandatory fortification of bread-making flour, introduced in September 2009, has significantly reduced the prevalence of folate deficiency, including—and importantly—for women of childbearing age. Although not yet confirmed, it is likely that this has been accompanied by a decrease in the incidence of neural tube defects [40]. Due to its low cost—generally around a few cents per person per serve—food fortification is recognised as an important and cost effective public health strategy. Providing vulnerable groups at risk of micronutrient deficiency with the required vitamins and/or minerals, is far more economical than treating the health problems related to micronutrient deficiencies [39].

Technical advances in food technology are leading to increased efficacy and application of food fortification techniques. For example, microencapsulation is increasingly used in the food industry to protect active ingredients such as vitamins, flavours and lipids from degradation. This is achieved by creating a protective layer of coating outside the active ingredient in order to minimise its degradation during food processing, storage and digestion.

4.4.2 The Defence environment

There is limited data available on the CR fortification practices used by other nations. However, the available information indicates that like Australia, the United States of America (USA) (R Trottier [Department of Defence Combat Feeding Directorate] 2010, pers. comm., 6 November), Germany (G Böse 2010, pers. comm., 4 November) and Slovenia (L Pograjc 2010, pers. comm., 29 October) fortify ration components. It is also likely that other nations with nutrient specifications for their CRP, for example Canada, New Zealand and England, are also using fortification as a means to meet these requirements [41].

The USA has no current policy that specifically addresses the fortification of ration components. However, like Australia, the USA has nutrient specifications, in their case presented as the 'Nutritional Standards for Operational and Restricted Rations'. Fortification is used to enable CR to meet or exceed these requirements and for nutrients to still be available to the consumer after long periods of storage (R Trottier [Department of Defence Combat Feeding Directorate] 2010, pers. comm., 6 November). It should be noted that fortification requirements, as expressed in specifications for Australian CR components, may not necessarily be achieved nor enforced.

Germany fortifies beverage powder and mineral water with thiamin, riboflavin, niacin, folate, vitamins B6, B12, C, A and E and calcium. Germany also fortifies ration components with pantothenic acid, biotin, sodium, potassium, magnesium, phosphorous, chloride and iron (G Böse 2010, pers. comm., 4 November). Slovenia fortifies its candy ration component with thiamin, riboflavin and the vitamins B6 and C (L Pograjc 2010, pers. comm., 29 October).

Table 3 provides a comparison of the fortification of Australian and USA CR components. In Australia and the USA (R Trottier [Department of Defence Combat Feeding Directorate] 2010, pers. comm., 6 November) fortified components are used in all varieties of CR. As indicated in Table 3 the USA fortifies many more CR components with a greater variety of nutrients compared with Australian fortification practices. Of particular interest is the fortification of USA CR components with the nutrients—folate, vitamin B6, vitamin D, vitamin E and calcium—all of which have been identified as nutrients of concern in the CR1M according to our data.

Table 3: Comparison of the fortification of Australian and United States military rations.

Nutrient	Australia	United States
Thiamin	Baked beans, ration chocolate, retort meals	Cheese spread, peanut butter, first strike bar, orange beverage base, cocoa
Riboflavin	Baked beans, retort meals	First Strike Bar ™, orange beverage base
Niacin	Baked beans, retort meals	First Strike Bar ™, orange beverage base
Folate		First Strike Bar ™
Vitamin B6		Cheese spread, peanut butter, First Strike Bar ™, orange beverage base, cocoa
Vitamin B12		First Strike Bar ™
Vitamin C	Baked beans, ration chocolate, retort meals, sport beverage powder	Peanut butter, First Strike Bar ™, beverage bases
Vitamin A	Ration chocolate, chocolate beverage powder	Cheese spread, peanut butter, cocoa
Vitamin D		Cheese spread, First Strike Bar ™, pudding, dairy shake, orange beverage base
Vitamin E		First Strike Bar ™, orange beverage base
Calcium		Crackers, snack bread, cheese spread, pudding, dairy shake, orange beverage base
Zinc		First Strike Bar ™

4.5 Supplementation

4.5.1 The general community

Australian Government policy considers dietary (vitamin and mineral) supplements not as food items, but as forms of medicine[10]. In Australia, 'complementary medicines' is the term used to describe products containing vitamins, minerals, herbs and dietary supplements. They are regulated as medicines under the Therapeutic Goods Act 1989, by the Therapeutic Goods Administration (TGA) [43]. This is consistent with the policy on fortification which states:

> "This policy does not apply to products that should be or are regulated as therapeutic goods. This should not lead to a situation where generally recognised

[10] A dietary supplement is "a product taken orally that contains one or more ingredients that are intended to supplement one's diet and are not considered food" [42]

foods, through fortification, become like or are taken to be therapeutic goods" [38].

Many of the claims made by manufacturers of supplements are not based on sound clinical trials and many assumptions are made about the active ingredient/s [43, 44]. There is limited data on the efficacy and safety of complementary medicines, and due to the generally self-prescribing nature of these medicines it is often difficult for consumers to make safe and appropriately informed choices [44].

Nutritional supplementation works best when a specific nutrient deficiency has been identified at the individual level [12, 44]. Supplementation is not often used at the population level. It may be efficacious in a population sub-group when a nutrient deficiency has been clearly defined and supplementation occurs in conjunction with appropriate education of the target population [45]. Supplementation can be administered quickly and produce almost immediate effects. However it is heavily reliant upon the motivation of target individuals to comply with the prescribed treatment. Non-compliance with the recommended dose is also of concern if individuals take more than is prescribed, which may lead to adverse health consequences due to accidental over-dosing [12].

4.5.2 The Defence environment

Supplements are not currently issued to Australian military personnel as part of their rations. As mentioned, specifications exist for the fortification of a variety of components with the principle aim of providing sufficient levels of key nutrients via CR feeding [1]. According to the ADF Commanders Guide to Nutrition, compendium 2 to chapter 2 of the Defence Catering Manual, vitamin and mineral supplements are not required if a balanced diet meeting energy needs is consumed [46].

Similar to the stance of the ADF, the US Office of the Surgeon General, Department of the Army, does not advocate the use of vitamin/mineral tablets in CR. They advocate the consumption of food components that provide adequate macronutrients and micronutrients (R Trottier [Department of Defence Combat Feeding Directorate] 2010, pers. comm., 6 November). This is reiterated in United States Army Research Institute of Environmental Medicine (USARIEM) Technical Note TN-01/4 [47], that states vitamin supplementation is not needed if a soldier consumes the recommended three meals per day, since US rations provide more than the recommended nutrients for this population group. Extra nutrients that are provided in the ration packs via fortification ensure that an adequate intake of vitamins should occur even when personnel do not consume their entire ration at every meal [47].

The use, efficacy and safety of supplements has been under investigation for many years in both Australian and international military settings [5, 31, 48]. A DSTO study conducted with female officer cadets on the use and efficacy of an iron supplement is of particular interest. The authors noted that good dietary advice is always appropriate for the prevention and treatment of iron deficiency and recommended that a nutrition education program be introduced. It was also recommended that the iron status of female officer cadets should be monitored and any suspected cases of iron deficiency (or iron overload) should be referred to a medical professional. Self-administered iron supplementation was not recommended and any iron supplementation should be administered under medical supervision [31].

An in-house DSTO study, investigating the acceptability of supplements within the ADF, found that 41% of respondents were currently consuming supplements, with 80% regularly taking supplements. A similar study of male recruits entering US Army Special Forces and Ranger training found that 37% of the recruits were current supplement users and 19% used supplements on a daily basis [49]. The DSTO study revealed that ADF personnel would be acceptant of supplements supplied with CRP, however general compliance with the consumption of the supplements is another issue. The report also stated that supplementation should be considered as a treatment for nutrient deficiency and handled on a case-by-case basis by a medical professional. It was concluded that ensuring nutritious food is provided to ADF personnel under all working conditions is a better option than the provision of medication.

DSTO has also investigated the nutritional determinants of bone health of male and female trainees. The study concluded that nutrients important to bone health, such as calcium, are likely to be deficient in military trainees. It was recommended that the ADF provide nutritional education, promote healthy behaviours such as cessation of smoking and a reduction in alcohol consumption, promote the consumption of dairy products and provide additional food sources of calcium. Calcium supplementation should also be considered under certain situations, such as during conditions of high strenuous physical activity and activity in hot climates, when CRP are the main food source [50].

Due to the classification of supplements as medicines under the Therapeutic Goods Act 1989 [51] and the findings from the research discussed above, we conclude that supplementation should remain a medical issue and be dealt with on an individual basis. Supplementation is therefore not considered as an option for improvement to the nutrient profile of Australian CR.

5. Addressing the Current Nutrient Concerns

A number of nutrients, including thiamin, riboflavin, niacin, folate, vitamin B12 and vitamin C, are supplied in CRP by only a small number of components. Adequate intake of these nutrients is reliant upon the complete consumption of these components, some of which are known to have low consumption rates. For this reason a greater spread of these particular nutrients should be considered throughout the components of CRP to increase the likelihood of adequate nutrient intake. The following sections highlight which options (detailed in section 4) could be used to improve the nutrient content of CRP. Options for improving the availability of specific nutrients in CRP are summarised in Appendix C.

5.1 CRP configuration

The supply and use of CRP has encountered problems owing to the inter-related issues of: under-consumption, not being tailored to specific operational environments and a somewhat rigid combat rationing system. It is likely that these problems may be ameliorated through improvements to the CRP logistics chain and re-configuration of current CRP.

Tailoring CRP to every operational situation would not be cost-effective. Rather, designing options that provide greater variety, flexibility and can readily accommodate future CRP changes, may align better with acute requirements than the CRP currently in use. DSTO has conducted studies on various CRP configurations including a hot weather ration [18], light-weight ration, part-day ration, whole-day meal-based, whole-day snack-based and a number of modular rationing concepts [3]. These concepts have been well received by both key stakeholders and users, indicating that further investigation of these options is warranted.

The specifications for CR food components are being reviewed during 2012/13. The new specifications place a greater emphasis on functional and performance based requirements. This should facilitate the development of an appropriately balanced suite of CR components and simplify menu design.

The configuration design should be based on defined user requirements that provide the foundation for estimating nutritional requirements for each type of CR. Selection of components should be such that design/performance criteria are met including (but not limited too) nutrient levels, consumer acceptability, shelf life and physical characteristics. DSTO is investigating options to sufficiently align with these criteria. Due to the numerous aspects involved in the investigation of viable options for the design configuration of CRP, it is difficult to identify at this stage which particular nutrients would benefit from each option.

Cost is a very large driver of CRP composition. However, through the identification of suitable COTS and MOTS products and ensuring that product component specifications are met, it is likely that a cost effective means of producing CRP may be provided whilst meeting the nutritional needs of the consumers.

5.2 Defence-specific component formulation

The Defence-specific components currently contained in Australian CR include the main meals (retort and freeze-dried), ration chocolate, fruit and fruit cake bars, muesli cereals and instant noodles (D King [Lands System Division, DMO] 2012, pers. comm., 13 December). Modifications to the formulation of these products, some of which are discussed in section 5.4 on fortification, should be considered as a means of improving the nutritional content of CRP. The following will consider the use of key ingredients to assist in improving the nutritional quality of these products.

Our results indicate that the protein content of CR1M menus, except for menu A, is sub-optimal. DSTO studies have shown over many years that the main meal items are highly consumed [18, 52, 53], therefore, although these items already provide most of the protein in CRP, the quantity of protein and the quality of the protein containing ingredients should be improved.

The new component specifications place a greater emphasis on the protein content, including categorisation of the meals as low, medium or high protein. This should facilitate the composition of menus that provide sufficient protein for consumers to meet their requirements. If protein quantity is improved by increasing the amount of meat provided in main meal items, this will also assist in enhancing the amount of iron provided in CRP.

In-house DSTO studies have determined “marginal acceptability” sensory ratings for salmon and pasta mornay during initial product quality testing. This product failed sensory performance criteria following 6 months storage at 30°C. Commencing with the 2012/2013 procurement of the CR1M, salmon and pasta mornay will no longer be included in any menu. Instead a chilli tuna and pasta dish will be used. It is likely that this dish will be a good source of B12 due to the presence of tuna. However, to confirm this, nutrient analysis of this meal is required.

The vitamin E content of CR1M menus, except menu H, is either marginal or below the MRDI. Efforts to make all CR nut-free is contrary to nutritional advice provided by DSTO in a report on allergens in CRP [54]. Nut and seed products are highly acceptable to soldiers [54] and are excellent sources of vitamin E and essential fatty acids, therefore removal of nuts places the majority of CR users at a disadvantage. As a natural source of important nutrients, the re-introduction of CR components containing nuts and nut products should be considered. The main meals, muesli mix varieties and fruit cake are current Defence-specific components that would be appropriate for the inclusion of these ingredients. In addition, eat-on-the-go type snack foods such as nuts and trail mixes could be formulated for use in CRP.

Greater use of vitamin E rich ingredients, such as nuts, seeds, vegetables and vegetable oils (e.g. sunflower), in retort and FD meals would increase availability of this nutrient. Vitamin E is generally not destroyed during the normal cooking of meat and vegetables [16] and therefore is likely to be maintained in sufficient concentrations in these CR components until the time of consumption. Our data indicates that vitamin E is quite stable in retort meals during storage.

Levels of vitamin K in all CR1M menus are sub-optimal, both pre- and post-storage. Vitamin K is rarely used as a food fortificant but can be found in supplements and infant formula [16, 17]. Providing additional vitamin K in CRP is best achieved through the use of specific vitamin K rich ingredients. Green leafy vegetables are excellent sources of vitamin K. Some unrefined vegetable oils including canola, soybean and olive oil are also rich sources of vitamin K [14]. Increasing the use of vegetables in the preparation of main meals and the use of oils[11] high in vitamin K in the preparation of CR components, would greatly increase the amount of vitamin K in CRP [16]. Current Defence-specific

[11] A problem with some vegetable oils is the risk of rancidity developing during storage. This needs to be managed when vegetable oils are used in the formulation of CR components.

components that could be used for the delivery of additional vitamin K include the main meals (additional vegetables, vitamin K rich vegetable oils), muesli mixes, fruit cake (vegetable oils) and the instant noodle varieties (vegetable oils).

All forms of vitamin K are relatively stable to heat [17]. Vitamin K has been found to be relatively stable in raw vegetables that have been processed by heat, freezing or irradiation. Heat processed vegetables stored at temperatures of 24–27 °C displayed no appreciable loss of vitamin K after 15 months of storage [55]. Based on the literature and our own data, the stability of vitamin K in CRP components is not a significant concern.

A Defence-specific, specially formulated food product, similar to the First Strike Bar ™ (FSB) (US Army), is worthy of consideration for inclusion in Australian CRP. This bar provides a large array of nutrients via product formulation using key ingredients and fortification. Currently the FSB uses specific ingredients to provide nutrients such as canola oil for vitamin K and whey protein concentrate for additional protein. The FSB is fortified with a number of nutrients including thiamin (thiamin mononitrate), riboflavin, niacin (niacinamide), folate (folic acid) and vitamin E (DL-alpha-tocopherol acetate)[12]. Table 3 details the nutrients provided in this food item.

5.3 COTS products[13]

To improve the nutritional value of CRP, DSTO has previously recommended to DMO that a COTS, high protein beverage powder be used to replace the current chocolate beverage powder. The inclusion of a COTS beef snack bar in all menus commenced with the 2012/2013 procurement of the CR1M. It is estimated that the inclusion of the current COTS tuna varieties, the beef snack bar and the COTS high protein beverage powder (replacing the current chocolate beverage powder) would result in the provision of sufficient protein in most menus. Menus F and H would remain marginally below the RNC/MRDI, providing 94% and 87%.

An additional protein source for the CR1M is the replacement of existing muesli mixes with a COTS fortified product. There are commercially available muesli varieties that are fortified with a number of nutrients that would be beneficial to the nutrient profile of the CR1M menus. It is estimated that an additional 5.6 g of protein would be made available if the current muesli item were to be replaced with a COTS muesli product high in protein. The addition of a high protein muesli mix, high protein beverage powder and a beef snack bar to all menus would ensure that all menus meet the protein, folate, niacin and vitamin E nutritional requirements. The combination of the muesli mix and high protein beverage powder would also improve the amount of vitamin A per menu, however the majority of menus would still fall short of the RNC and MRDI.

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[12] Information provided on FSB wrapper.

[13] Nutritional data for suggested COTS products obtained from nutritional labels on packaging and FoodWorks Professional 2009 (Xyris software) have been combined with the CR1M nutrient data presented here to estimate the extent that COTS products may improve the content of particular nutrients in CR. The following is a discussion on the results of this process.

Replacement of the existing chocolate beverage powder with the COTS, high protein beverage powder would also increase the calcium and iron content of the CR1M to recommended levels. This high protein beverage powder would also provide an additional 0.4 mg and 0.6 mg of thiamin and riboflavin, respectively. The replacement of the existing chocolate beverage powder is planned for the 2015/2016 procurement of the CR1M[14].

The replacement of the existing muesli mix with COTS, high protein, fortified, muesli mix as a common item in all menus is likely to result in all menus meeting the niacin MRDI post-storage. The muesli mix is capable of providing an additional 44 mg of calcium and 4.7 mg of iron. It is also possible for this product to provide 37%, 25% and 20% of the MRDI for thiamin, riboflavin and fibre respectively.

Vitamin B12 in the diet is supplied predominantly from animal-based foods, such as red meat, fish and dairy products [14]. The tuna in the CR1M is a very good source of vitamin B12; it is also highly acceptable to troops [18]. The inclusion of tuna as a common item in the CR1M menus, as recommended above to improve protein content, would also result in sufficient levels of vitamin B12 to meet the MRDI at the time of consumption. This is similar to a conclusion about the US assault ration which was designed for short term high intensity operations—if some of the protein is from animal sources then fortification with vitamin B12 is not necessary [48].

Vitamin E levels in menus B and G are sub-optimal pre- and post-storage and marginal for menus A, D and F post-storage. The inclusion of a COTS nut product such as the previously used hazelnut-based, confectionery spread and/or a trail mix is likely to provide sufficient vitamin E and enable a greater distribution of this nutrient over a variety of components. DSTO has previously recommended to DMO that a trail mix and high oleic roasted peanuts be investigated for inclusion in CRP when packaged to maximise shelf life. High oleic peanuts have a shelf life approximately twice that of normal peanuts and when packaged to maximise shelf life are likely to meet Defence storage guidelines for CRP components [56]. Sufficient vitamin E could be provided, if nuts and seeds were to be included in CRP.

The identification of suitable COTS products, such as muesli, muesli bars and crackers, with the main ingredient being wholegrain, would also improve the availability of vitamin E. The inclusion of vegetable-based (not potato) chip snacks could also add to the vitamin E content of the CR1M. These products are capable of providing approximately 25% of the RNC/MRDI for vitamin E. However, the storage properties and packaging requirements of such items require investigation before a decision on their inclusion in CRP could be made. These products are also excellent sources of vitamin C, potentially providing approximately 50% of the MRDI for vitamin C.

To improve the vitamin K availability in CRP it is recommended that consideration be given to the inclusion of vegetable based, COTS snack products, such as vegetable-based,

[14] *Defence Catering Working Group Committee Meeting*, Campbell Park Offices, Canberra: 8th November 2012.

chip snacks cooked in canola oil. Another option for consideration is to replace the current tuna varieties with tuna in a vegetable oil that is rich in vitamin K.

Under the Code, a variety of products are allowed to be voluntarily fortified with up to 200 mg per serve of calcium [57]. COTS products that have been fortified with calcium should be considered for inclusion in CRP, for example chewing gum, ready-to-eat breakfast cereals, instant soup powders, formulated beverages (e.g. sports beverages and beverage powders), biscuits and milk powder.

5.4 Fortification

As discussed, fortification is the addition of vitamins and minerals to foods. The following section will detail the options for the use of fortification to improve the nutrient content of CR components. The discussion mainly focuses on the fortification of particular food groups but also provides a general section on the fortification of food with specific nutrients.

5.4.1 Cereals

The amounts of vitamin A, the B-group vitamins—thiamin, riboflavin, niacin, vitamin B6 and folate— and iron should be increased in CR1M. Fortification with any and all these vitamins is achievable. The use of a flour fortified with a vitamin pre-mix—containing vitamin A, the B-group vitamins and iron—should be considered for the production of flour-based CR products, such as biscuits and noodles [58]. These vitamins have been found to be stable during manufacture, storage and cooking of the noodles [58, 59]. The use of this vitamin pre-mix should also be considered for the fortification of cereal-based products such as the muesli bars, muesli mix and other cereal based items. All of these nutrients have been found to have good stability in these food matrices [14, 16]. Cereals, grains and their flours are excellent vehicles for the delivery of thiamin fortificants, providing a particularly stable matrix when stored in the absence of moisture and light [17, 60]. The bioavailability of the folic acid used to fortify foods is approximately 85% compared with 50-60% bioavailability of naturally occurring folates in food [61-63].

The seasoning sachet used to flavour the noodles would also provide a stable matrix for the delivery of these vitamins. In other studies, little loss of the vitamin A, vitamin C, thiamin, riboflavin, niacin, vitamin B6, vitamin B12, folate, biotin, pantothenic acid and vitamin E added to the seasoning mix was observed after 6 months storage at 25 °C [59, 64]. Currently, thiamin and folate are added to commercial grain and flour based products [16, 37].

The level of iron contained in CRP may also be enhanced by using wheat flour fortified with iron for the production of components such as biscuits and noodles. Iron fortificants are very stable during the production and cooking processes of noodles. Approximately 70% of the iron fortificant—sodium iron ethylene-diamine-tetra-acetic acid—has been found to leach into the soup accompanying the noodles, where it is stable [65]. Therefore, the fortification of noodles with iron (and other water soluble nutrients) will be more successful if consumers choose to consume the soup and noodles, not just the noodles.

Fortification of wheat flour with iron and B vitamins, including folic acid, thiamin, riboflavin and niacin (as suggested above), is mandatory in many countries such as Argentina, Canada, Chile, Columbia, Costa Rica, Cuba, Mexico, Paraguay and Saudi Arabia [64]. Ready-to-eat breakfast cereals have been commercially fortified with iron for many years [66]. The seasoning sachet for the instant noodles may be another suitable vehicle for fortification with iron [59]. In food manufacturing for the general population, cereals are the most widely used vehicles for iron fortification. Milk products, sugar, and soya sauce have also been successfully fortified [60]. The use of a vitamin pre-mix for fortification may be an easy and cost effective means of providing a variety of nutrients across a range of CR components.

5.4.2 Main meals

The main meals in menus A to G are good to excellent sources of riboflavin and vitamin C. To increase the availability of riboflavin and vitamin C in menu H, alternative main meal items containing higher concentrations of these nutrients is required. Since retort meals are specialised products for ADF, a replacement main meal could be fortified with riboflavin and ascorbic acid to ensure sufficient amounts of these nutrients are available at the time of consumption. As this report has demonstrated, riboflavin losses during storage are relatively minor and therefore only a small overage[15] would be required. The current military packaging ensures that riboflavin is not denatured by light [15]. Although our results indicate there was a substantial loss of vitamin C from the main meal items, sufficient amounts are still available at the time of consumption. The fortification of the main meal items with vitamin A and iron, a stable vehicle for both nutrients, should also be considered. The fortification of main meals with niacin should continue as they are the main contributor of this vitamin.

FD meals currently used in the Patrol Ration One Man have been found to be suitable vehicles for fortification with vitamin C and vitamin E [67]. The stability of the B vitamins should be investigated to determine whether this is also a suitable matrix for these nutrients. Potentially, FD meals could be used as stable matrices for the delivery of a range of vitamins to the soldier and, if used in CR1M, simultaneously assist in addressing the protein shortfall in all but one menu.

5.4.3 Dairy

Skim milk powder is a minor component and not a major contributor of riboflavin and vitamin A in the CR1M, however it is a highly suitable vehicle for the delivery of these nutrients due to its low water activity [16]. Riboflavin is currently used to fortify commercially available dried milk products [14]. Vitamin A in milk powder is very stable when stored for long periods at ambient temperature, including tropical ambient conditions, provided packaging is impervious to air, light and moisture [16]. The use of a moderate fat milk powder will also improve the stability of added vitamin A and should be considered as an alternative to the existing skim milk powder.

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[15] The amount of excess fortificant added to allow for processing and storage losses.

In Australia, vitamin D fortification of margarine and edible oil spreads is mandatory and voluntary fortification with vitamin D is permitted in dried milks, modified milks and skim milk, cheese and cheese products, yoghurts, dairy desserts and butter [57]. A study on the fortification of milk with vitamin D, found that the bioavailability of vitamin D added to the milk was greater than that of a supplement [68]. For the above reasons, vitamin D fortification of milk powders included in CRP should also be considered.

5.4.4 Specific nutrients

Vitamin B6 is found in all natural, unprocessed foods. Major contributors of vitamin B6 in the diet are lean meats, fish, nuts and whole grains. There is a substantial loss of vitamin B6 from whole grains during the refining process to make flour. Vitamin B6 is denatured during prolonged heat treatment and storage, however is more stable in plant rather than animal food sources [16]. Due to the high RNC for vitamin B6—a level difficult to achieve through the use of natural food sources—fortification is the best means of ensuring that sufficient vitamin B6 is present after manufacture and available at time of consumption. It is recommended that further investigation into suitable vehicles for the delivery of vitamin B6 be identified, and if fortification is to occur, the components are chosen based on these characteristics. It is likely that plant-based CRP components would be the most stable vehicles for vitamin B6 fortification [16].

Investigation into novel packaging for the current fortified sports beverage powders containing high concentrations of vitamin C should be considered due to the poor consumption of this product. Vitamin C fortificants are stable in matrices of low water activity, such as the sports beverage powder [69]. A DSTO study, investigating Australian freeze dried (FD) meals as a vehicle for various vitamin fortificants, found that vitamin C was very stable in that low moisture matrix [67].

Due to marginal and inadequate levels of vitamin E in CRP and the exclusion of components containing nuts, the fortification of highly acceptable and consumed components with vitamin E should be considered. Inclusion of fortified components in all menus, particularly menus B and G, will ensure that all CR1M menus meet the RNC/MRDI for vitamin E.

Investigation into potential vehicles for the delivery of nutrients in CRP should include consideration of the fortification practices of other military organisations. The suitability of current Australian CRP components for fortification should be determined and complemented by the development of prototype, fortified components to ensure RNC and MRDI can be met.

6. Conclusions

Due to the activity levels of Australian soldiers during field exercises and operations, the length of time they may be rationed with CRP and the widely observed and documented under-consumption of ration packs, ensuring a sufficient intake of necessary nutrients has proved to be problematic.

This report is based primarily on the nutritional composition analysis of the 2008-09 build of CRP, prior to the commencement in 2010 of HLTHSPO program of continuous improvement activities for CRP. The CRP evaluated in this study, did not fully meet nutritional guidelines and some practicable options for improvement are provided. The information will be of value to HLTHSPO as it continues to improve CRP and may be used as a reference point for a future assessment of the impact of those improvements. As more data become available, and as changes are made to the formulation of components and the configuration of CRP, the nutritional quality of CRP should be regularly reassessed to determine its overall efficacy in providing the types and amounts of the required nutrients.

Based on our studies and determinations, we conclude:

- There were a number of nutrients that did not meet the RNC/MRDI before and after storage.
- Priority should be given to rectifying inadequate levels of protein, folate, vitamin B6, vitamin A, vitamin E, vitamin K, iron and calcium.
- Vitamin D status and adequate intake is of concern for the general Australian population and should be investigated as a matter of some urgency for the Australian military population to determine the need for fortification.
- There are concerns about the provision of thiamin, vitamin B12 and vitamin C via CRP. Although the availability of these nutrients is not as concerning as those discussed above, an investigation into improving their availability to consumers would be in order for ensuring better nutrition and overall wellbeing.
- Riboflavin is stable during storage. Some menus did not meet the RNC prior to storage, but all menus met the MRDI post-storage. For this reason, it is suggested that the RNC for this nutrient, currently set at 3 times the MRDI, should be reviewed. It is suggested that setting the RNC for riboflavin to just slightly above the MRDI would suffice.
- Many of the nutrients are supplied in adequate quantities by only 2 or 3 components. Adequate nutrient intake is reliant upon the consumption of a small number of food items.
- The fortification of the main meal items, ration chocolate and sports beverage powder, as per current requirements, remains warranted at this time.

- The use and provision of supplements is recognised as a medical concern and has not been considered as an option to address any inadequacies in the nutrient content of CRP.

Options to improve the nutritional quality of CRP include:

- Re-configuration of the suite of rations;
- Defence specific component formulation (MOTS);
- Increased use of COTS products;
- Fortification (MOTS, COTS, ingredients); or
- A combination of these options.

This report provides detail on the application of these options to assist DMO to make informed decisions on improving the nutritional properties of CRP. The continued and increased use of COTS items and fortification appear to be an effective and balanced option. This should, however, be seen as contingent on results of DSTO investigations into the design configuration of CRP. Consideration will also need to be given to the legal ramifications of fortification, cost, logistics and packaging aspects of CRP production, before deciding on the preferred approach to improving the nutritional content of Australian CRP.

To counteract the selective consumption of CRP components by ADF members, a greater spread of nutrients throughout CRP menus should be considered. Improvements to the availability of a number of nutrients can be provided by a small number of COTS items if included in CRP as common items. The use of these COTS products could also increase the spread of nutrients available from a variety of CR components.

The fortification of CR components should take into account the voluntary fortification provisions detailed in the Code. As other countries are fortifying foods for both the general and military populations, there is already a base of knowledge available on fortification of products that can be used when considering fortification of Australian CRP. Suitable and sufficient COTS products (i.e. fortified with the desired nutrients at appropriate levels) may already be available as options to consider for inclusion in CRP.

Fortification through the use of vitamin pre-mixes may also offer an easy and cost effective means of providing sufficient quantities of various nutrients. Fortification can also provide additional health benefits resulting from the higher bioavailability of many fortificants. This would further increase the likelihood of adequate nutrient intakes.

To ensure an intake of sufficient quantities of those nutrients which are not shelf-stable, fortification may be the only effective means as prescribed storage regimes for current CRP can lead to significant diminution in the levels of nutrients over the time for which CRP are stored.

The exclusion of components containing nuts from CR has led to a decrease in the amount of vitamin E available. Nuts and seeds are excellent sources of vitamin E and essential fatty acids and are potentially an efficient and cost effective means of providing these nutrients to soldiers.

A number of practicable solutions have been presented in this report that would improve the nutritional profile of current Australian CRP. A range of specific recommendations provides a means to improve the current CRP in stages.

7. Recommendations

The following recommendations include some practicable options to improve the nutritional quality of CRP:

a. Continue with the current fortification regime for the main meal items, ration chocolate and sports beverage powder. This includes fortification of the vegetable-based main meals, for example baked beans, with niacin.

b. Consider the inclusion of tuna varieties, beef snack, the previously recommended high protein chocolate beverage and a nutrient fortified muesli mix in all menus of the CR1M as common items to improve the protein, folate, niacin, calcium, vitamin A, vitamin E and vitamin B12 contents.

c. Investigate the availability of vitamin E rich foods as potential components.

d. Reintroduce nuts and nut products. Items suitable for inclusion would be the hazelnut-based confectionery spreads, trail mix and high-oleic, roasted peanuts. These are good sources of vitamin E.

e. Investigate suitable vehicles for the delivery of vitamin B6 fortificants.

f. Replace the main meal in menu H with another containing higher levels of riboflavin and vitamin C.

g. Investigate the fortification of FD meals with a variety of nutrients, including the B vitamins, vitamin C and vitamin E. Consider the inclusion of a fortified FD meal in CR1M.

h. Determine the vitamin D content of CRP. Consider fortification if deficiencies are identified.

i. Replace skim milk powder with moderate-fat milk powder fortified with vitamin A and, potentially, vitamin D.

The consideration of these options should include serviceability (acceptance, reliability, availability, consumption), cost, legal ramifications and supply chain management aspects.

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Appendix A: Summary of CRP component data sources

Product (2008/09 items)	Menu	Data source	
		Initial condition	End of storage
Braised beef and gravy	A	used data from meatballs, sweet and sour sauce, 2008/09 data; except protein source from PIF for braised beef and gravy	2008/09 data
Chicken, BBQ	A	2008/09 data	2008/09 data
Beef teriyaki	B	used data from meatballs, sweet and sour sauce, 2008/09 data except protein source from PIF for beef teriyaki	2008/09 data
Chicken curry	C	used data from BBQ chicken, 2008/09 data; except protein source from PIF for chicken curry	2008/09 data
Chicken italiano	D	used data from BBQ chicken, 2008/09 data; except protein source from PIF for chicken italiano	2008/09 data
Sausages and vegetables	C, F	2008/09 data	2008/09 data
Beef BBQ	D	used data from meatballs, sweet and sour sauce, 2008/09 report; except protein source from PIF for beef BBQ	2008/09 data
Meatballs, sweet and sour sauce	F	2008/09 data	2008/09 data
Beef mince with spaghetti	G	used data from beef mince with tortellini, 2008/09 data; except protein source from PIF for beef mince with spaghetti	2008/09 data
Beef mince with tortellini	E	2008/09 data	2008/09 data
Chilli con carne	G	used data from beef mince with tortellini, 2008/09 data; except protein source from PIF for chilli con carne	2008/09 data
Salmon and pasta mornay	B	The menu contained salmon and pasta with cheese sauce, not salmon and pasta mornay, 2008/09 data	2008/09 data
Baked beans	H	2008/09 data	2008/09 data
Vegetable curry	H	2008/09 data	2008/09 data

Product (2008/09 items)	Menu	Data source	
		Initial condition	End of storage
Lamb with rosemary	E	used data from meatballs, sweet and sour sauce, 2008/09 data; except protein source from PIF for lamb and vegetables with rosemary	2008/09 data
Tuna in springwater	A	used data from tuna with dried tomato, 2008/09 data	2008/09 data
Tuna with dried tomato	D, H	2008/09 data	2008/09 data
Soup, savoury	A, H	2008/09 data	2008/09 data
Soup, tomato	E, F	used data from soup, savoury, 2008/09 data; except protein source from PIF for soup, tomato	2008/09 data
Soup, beef	B, G	2008/09 data	2008/09 data
Soup, chicken	D	used data from soup, beef, 2008/09 data; except protein source from PIF for soup, chicken	2008/09 data
Sports beverage powder, orange	G	used data for vitamin C only, from sports beverage powder, orange, 2010/11 data	NA *
Sports beverage powder, mixed berry	F, H	used data for vitamin C only, from sports beverage powder, grape 2010/11 data	NA *
Sports beverage powder, tropical	A, C, D, E	used data for vitamin C only, from sports beverage powder, lemon lime , 2010/11 data	NA *
Sports beverage powder, grape	B	used data for Vitamin C only, from sports beverage powder, grape, 2010/11 data	NA *
Chocolate beverage powder	All menus	2008/09 data	2008/09 data
Biscuit, scotch finger	F, G	2009/10 data	2009/10 data
Biscuit, vitalife wellgrain	B, C, F, G	used data from biscuit, crispbread, 2009/10 data	2009/10 data
Biscuit, shrewsbury	B, C, H	used data from biscuit, shrewsberry, 2000/01 data	NA *
Biscuit, crispbread	A, D, E, H	2009/10 data	2009/10 data
Biscuit, krispie	A, D, E	used data from biscuit, nice, 2009/10 data	2009/10 data

Product (2008/09 items)	**Menu**	**Data source**	
		Initial condition	**End of storage**
Confectionery spread, chocolate	A, F	2008/09 data	2008/09 data
Confectionery spread, vanilla	C, D, E, H	used data from confectionery cream spread – white hazelnut, 2008/09 data	2008/09 data
Fruit grains, apricot	A, F, H	2009/10 data	2009/10 data
Fruit grains, mix berry	C	2009/10 data	2009/10 data
Fruit Grains, blackcurrant	B, G	used data from fruit grains, raspberry, 2009/10 data	2009/10 data
Fruit grains, strawberry	E	2009/10 data	2009/10 data
Fruit grains, raspberry	D	2009/10 data	2009/10 data
Fruit spread, raspberry	C, G	2009/10 data	2009/10 data
Fruit spread, plum	D, F	used data from fruit spread, raspberry, 2009/10 data	2009/10 data
Fruit spread, marmalade	B, H	used data from fruit spread, raspberry, 2009/10 data	2009/10 data
Fruit spread, blackcurrant	A, E	used data from fruit spread, raspberry, 2009/10 data	2009/10 data
Fruit, two fruits, diced	D, E, F	2008/09 data	2008/09 data
Fruit, peaches, diced	A, B, H	used data from peaches, clingstone, 2008/09 data	2008/09 data
Fruit, pears, diced	C, G	used data from pears, in cans, 2008/09 data	2008/09 data
Noodles, beef	C, F	2008/09 data	2008/09 data
Beef flavouring	C, F	2008/09 data	2008/09 data
Noodles, chicken	B, E	2008/09 data	2008/09 data
Chicken flavouring	B, E	2008/09 data	2008/09 data
Freeze dried rice	B	2000/01 data	NA *
Muesli bar, forest fruits	B, D, E, F, G, H	2009/10 data	2009/10 data
Muesli cereal, fruitful	A, E	2009/10 data	2009/10 data
Muesli cereal, natural	C, F	2009/10 data	2009/10 data

Product (2008/09 items)	Menu	Data source	
		Initial condition	End of storage
Muesli bar, apricot and coconut	B, C, D, G, H	2009/10 data	2009/10 data
Muesli bar, tropical fruits	A, B, D, G, H	2009/10 data	2009/10 data
Skim milk powder	A, C, E, F	2009/10 data	2009/10 data
Ration chocolate	All menus	2008/09 data	2008/09 data
Vegetable extract	All menus	2009/10 data	NA *
Cheddar cheese	All menus	2009/10 data	2009/10 data
Candy chocolate (M&M's)	All menus	2008/09 data	2008/09 data
Chewing gum	All menus	used data from chewing gum, PK, 2000/01 data	NA *
Candy, hard various	All menus	used data from candy hard, banana berry, 2000/01 data	NA *

Notes:
1) * no post storage data is available
2) PIF: Product Information Form, Australian Food and Grocery Council, accessible from: http://www.afgc.org.au/tools-guides-/product-info-form.html

Appendix B: 2008/09 CR1M menu sheet

AUSTRALIAN DEFENCE FORCE – COMBAT RATIONS ONE MAN

CONTENTS SHEET

The Combat Ration One Man is available in the eight menus shown below. Due to unavoidable circumstances, items may be substituted. Nutritional and Shelf Life information is available from Catering Fleet Technical Advisors. All suggestions / comments: Email crp.feedback@defence.gov.au

MENU A		MENU B		MENU C		MENU D	
Braised Beef and Gravy	1x250g	Beef Teriyaki	1x250g	Chicken Curry	1x250g	Beef BBQ	1x250g
Chicken, BBQ	1x250g	Salmon & Pasta Mornay	1x250g	Sausages & Vegetables	1x250g	Chicken Italiano	1x250g
Soup, Savoury	1x30g	Soup, Beef	1x30g	Bev Powder, Type II, Tropical	1x70g	Soup, Chicken	1x30g
Bev Powder, Type II, Tropical	1x70g	Bev Powder, Type II, Grape	1x70g	Biscuit, Shrewsbury	1x45g	Bev Powder, Type II, Tropical	1x70g
Biscuit, Crispbread	1x35g	Biscuit, Shrewsbury	1x45g	Biscuit, Vitalife Wellgrain	1x36g	Biscuit, Crispbread	1x34g
Biscuit, Krispie	1x33g	Biscuit, Vitalife Wellgrain	1x36g	Confectionary Spread – Vanilla	1x50g	Biscuit, Krispie	1x43g
Confectionary Spread – Choc	1x50g	Freeze Dried Rice	1x55g	Fruit Grains, Mix Berry	1x15g	Confectionary Spread – Vanilla	1x50g
Curry Powder	1x3.5g	Fruit Grains, Blackcurrant	1x15g	Fruit Spread, Raspberry	1x26g	Fruit Grains, Raspberry	1x15g
Fruit Grains, Apricot	1x15g	Fruit Spread, Marmalade	1x32g	Fruit, Pears, Diced	1x140g	Fruit Spread, Plum	1x26g
Fruit Spread, Blackcurrant	1x26g	Fruit, Peaches, Diced	1x140g	MB, Apricot & Coconut	1x32g	Fruit, Two Fruits, Diced	1x140g
Fruit, Peaches, Diced	1x140g	MB, Apricot & Coconut	1x32g	Muesli Cereal, Natural	1x60g	MB, Tropical Fruits	1x32g
MB, Tropical Fruits	1x32g	MB, Tropical Fruits	1x32g	Milk, Dried Skim	1x3g	MB, Apricot & Coconut	1x32g
Muesli Cereal, Fruitful	1x60g	MB, Forest Fruits	1x32g	Noodles Beef Flavour	1x47g	MB, Forest Fruits	1x32g
Milk, Dried Skim	1x3g	Noodles Chicken Flavour	1x47g	Sauce, BBQ	1x10g	Sauce, BBQ	1x10g
Sauce, Tomato	1x15g	Sauce, Sweet Chilli	1x10g	Sauce, Tomato	1x15g	Sauce, Tomato	1x15g
Sauce, Sweet Chilli	1x10g	Sauce, Tomato	1x15g			Sauce, Worcestershire	1x10g
Tuna in Springwater	1x85g					Tuna with Dried Tomato	1x85g

MENU E		MENU F		MENU G		MENU H	
Beef Mince w/ Tortellini	1x250g	Meatballs, Beef with Sweet and Sour Sauce	1x250g	Chilli Con Carne	1x250g	Baked Beans	1x250g
Lamb with Rosemary	1x250g	Sausages & Vegetables Curry	1x250g	Beef Mince with Spaghetti	1x250g	Vegetable Curry	1x250g
Soup, Tomato	1x30g	Soup, Tomato	1x30g	Soup, Beef	1x30g	Soup, Savoury	1x30g
Bev Powder, Type II, Tropical	1x70g	Bev Powder, Type II, Mixed Berry	1x70g	Bev Powder, Type II, Orange	1x70g	Bev Powder, Type II, Mixed Berry	1x70g
Biscuit, Crispbread	1x34g	Biscuit, Scotch Finger	2x35g	Biscuit, Scotch Finger	1x35g	Biscuit, Shrewsbury	1x47g
Biscuit, Krispie	1x43g	Biscuit, Vitalife Wellgrain	1x36g	Biscuit, Vitalife Wellgrain	1x36g	Biscuit, Crispbread	1x34g
Confectionary Spread – Vanilla	1x50g	Confectionary Spread – Chocolate	1x50g	Fruit Grains, Blackcurrant	1x15g	Confectionary Spread – Vanilla	1x50g
Fruit Grains, Strawberry	1x15g	Fruit Grains, Apricot	1x15g	Fruit Spread, Raspberry	1x26g	Fruit Grains, Apricot	1x15g
Fruit Spread, Blackcurrant	1x26g	Fruit Spread, Plum	1x26g	Fruit, Pears, Diced	1x140g	Fruit Spread, Marmalade	1x32g
Fruit, Two Fruits, Diced	1x140g	Fruit, Two Fruits, Diced	1x140g	MB, Tropical Fruits	1x32g	Fruit, Peaches, Diced	1x140g
MB, Forest Fruits	1x32g	MB, Forest Fruits	1x32g	MB, Forest Fruits	1x32g	MB, Tropical Fruits	1x32g
Muesli Cereal, Fruitful	1x60g	Noodles, Beef Flavour	1x47g	MB, Apricot & Coconut	1x32g	MB, Forest Fruits	1x32g
Milk, Dried Skim	1x3g	Muesli Cereal, Natural	1x60g	Sauce, Worcestershire	1x10g	MB, Apricot & Coconut	1x32g
Noodles, Chicken Flavour	1x47g	Milk, Dried Skim	1x3g	Sauce, Tomato	1x15g	Sauce, Sweet Chilli	1x10g
Curry Powder	1x3.5g	Sauce, BBQ	1x10g			Sauce, Tomato	1x15g
Sauce, Sweet Chilli	1x10g	Sauce, Sweet Chilli	1x10g			Tuna with Dried Tomato	1x85g
Sauce, Tomato	1x15g						

ADDITIONAL ITEMS COMMON TO ALL MENUS

Bev, Chocolate Powder	1x30g	Milk, Sweet Condensed	1x85g	Salt	1x2g	Matches, Safety, Vial	1
Bev, Coffee Instant	2x3.5g	Cheese Cheddar Canned	1x56g	Bag, Plastic, Resealable	1	Pads Scouring, Nylon	1
Bev, Tea Bags	2x2.5g	Chocolate Ration	1x50g	Bag, Plastic, Inner	1	Spoon Plastic	1
Sugar	8x7g	Vegetable Extract	1x15g	Rubber Bands, Size 32	2	Toilet Paper, Sheets	10
Candy Chocolate (M&M's)	1x55g	Chewing Gum,	2 pkts	Rubber Band, Size 61	1	Menu Sheet	1
Candy Hard Various	2x30g	Pepper, Black	1x2g	Can Opener Hand	1	Ingredient Sheet	1

Appendix C: Options to improve nutrient content of CRP

Nutrient of concern	Current Main Contributors	Options
Protein	Main meals, tuna and beef snack	Defence-specific component formulation: - specify proportion of protein that should be used to produce meat based retort meals; - development of a ADF specific food bar for inclusion into CR e.g. FSB. COTS products: - investigate the suitability of high protein COTS products as CR components. - potential COTS products include tuna, beef snack/jerky varieties, trail mixes, nuts, protein enriched, muesli mixes, flavoured beverage powders (e.g. sports formulated beverages and bars).
Thiamin	Main meals, high fat confectionery, vegetable extract	Defence-specific component formulation: - development of a ADF specific food bar for inclusion into CR e.g. FSB. COTS products: - investigate suitable COTS products fortified with this nutrient. - potential products include flavoured beverage powders (e.g. sports formulated products), muesli mixes, biscuits, ready-to-eat-breakfast cereals. Fortification: - fortify cereals and grains with thiamin. A vitamin pre-mix may be a suitable fortificant. - use flour fortified with a vitamin premix containing thiamin in the production of flour based CR components e.g. biscuits and noodles. - fortification of instant noodle spice sachet.
Riboflavin	Main meals, high fat confectionery and vegetable extract	Defence-specific component formulation: - development of an ADF specific food bar for inclusion into CR e.g. FSB. COTS products: - investigate suitable COTS products fortified with this nutrient. - potential products include flavoured beverage powders (e.g. sports formulated products), muesli mixes, milk powder, ready-to-eat-breakfast cereals. Fortification: - increased fortification of the main meals contained in menu H; - fortify cereals and grains with riboflavin. A vitamin pre-mix may be a suitable fortificant.

		- use flour fortified with a vitamin premix containing riboflavin in the production of flour based CR components e.g. biscuits and noodles. - fortification of instant noodle spice sachet. - fortification of skim milk powder.
Niacin	Main meals, high fat confectionery and vegetable extract	Defence-specific component formulation: - development of a ADF specific food bar for inclusion into CR e.g. FSB. - fortification of vegetable based main meals e.g. baked beans with niacin. COTS products: - investigate suitable COTS products fortified with this nutrient. - potential products include flavoured beverage powders (e.g. sports formulated products), muesli mixes, ready-to-eat-breakfast cereals. Fortification: - fortify cereals and grains using a vitamin pre-mix containing niacin. - use flour fortified with a vitamin premix containing niacin in the production of flour based CR components e.g. biscuits and noodles. - fortification of instant noodle spice sachet.
Folate	Cereal, main meals and canned fruits	Defence-specific component formulation: - development of a ADF specific food bar for inclusion into CR e.g. FSB. COTS products: - investigate the suitability of COTS products that are suitably fortified with folate, particularly cereal products, that are going to withstand standard storage requirements; - foods containing nuts as the base ingredient should also be considered. Fortification: - fortify existing CRP components at required levels; - use flour fortified with a vitamin premix containing niacin in the production of flour based CR components e.g. biscuits and noodles. - fortification of instant noodle spice sachet;
Vitamin B6	Main meals, soup powders and high fat confectionery	Defence-specific component formulation: - development of a ADF specific food bar for inclusion into CR e.g. FSB. COTS products: - investigate the suitability of COTS products that are suitably fortified with vitamin B6, particularly cereal products, that are going to withstand standard storage requirements; - foods containing nuts as the base ingredient should also be investigated. Fortification:

		- fortify existing CRP components at required levels; - use flour fortified with a vitamin premix containing vitamin B6 in the production of flour based CR components e.g. biscuits and noodles. - fortification of instant noodle spice sachet.
Vitamin B12	Main meals, tuna and dairy foods	Defence-specific component formulation: - replacement main meal for the salmon and pasta with cheese sauce. - development of a ADF specific food bar for inclusion into CR e.g. FSB. COTS products: - inclusion of tuna as a common item in all CRP menus. Fortification: - fortification of instant noodle spice sachet.
Vitamin C	Main meals and sports beverage powder	Defence-specific component formulation: - development of a ADF specific food bar for inclusion into CR e.g. FSB. Fortification: - continued fortification of main meals at current levels with vitamin C; - increased fortification of main meals in menu H, or replace with other meals fortified with sufficient vitamin C; - continue to fortify sports beverage powders with vitamin C, and investigate novel packaging of this product to encourage greater consumption; - include freeze dried meals, fortified with vitamin C, as a main meal option in the CR1M. - fortification of instant noodle spice sachet. COTS products: - investigate other COTS products with sufficient vitamin C for inclusion in CR. - investigate the suitability of vegetable (not potato) based chip snacks.
Vitamin A	High fat confectionery	Defence-specific component formulation: - development of a ADF specific food bar for inclusion into CR e.g. FSB. COTS products: - investigate COTS products with sufficient vitamin A for inclusion in CRP recommended products included muesli mixes and fortified flavoured beverage powders (e.g. sports formulated products). Fortification: - increase amount of vitamin A currently added to the main meals and skim milk powder; - fortification of items in the cereal group: either directly or via the use of fortified wheat flour for production of cereal components; - fortification of instant noodle spice sachet;

		- include freeze dried meals, fortified with vitamin A, as a main meal option in the CR1M. - use flour fortified with a vitamin premix containing vitamin A in the production of flour based CR components e.g. biscuits and noodles. - replace current skim milk powder with vitamin A enriched moderate fat skim milk powder.
Vitamin D	No data currently available	Further investigation into the amount of vitamin D available in CR and if it needs to be improved. Fortified milk powders (e.g. sports formulated products), cheese and cheese products and butter are potential options as CR components.
Vitamin E	High fat confectionery, main meals, cereals and canned fruit	Defence-specific component formulation: - Use of nuts and seeds as ingredients for the preparation of CR components. Suitable components include the main meals (retort and FD), muesli mix varieties, fruit cake. - Use of vitamin E rich vegetable oils in the preparation of CR components. Appropriate items include the main meals (retort and FD), muesli mix varieties, fruit cake, instant noodles. - development of a ADF specific food bar for inclusion into CR e.g. FSB. COTS products: - foods containing nuts and/or whole grains, as the base ingredient should be considered for example muesli bars, muesli mixes, trail mixes, high oleic roasted peanuts as potential CR components. - re-introduction of hazelnut based confectionery spread. - investigate suitability of vegetable (not potato) based chip snacks. Fortification: - investigation of suitable vehicles for the delivery of vitamin E from a variety of ration components. - fortification of instant noodle spice sachet. - fortification of FD meals to be used as main meal options in the CR1M.
Vitamin K	Cereals, main meals and high fat confectionery	Defence-specific component formulation: - increased amount of vegetables in main meals (retort and FD). - use of vitamin K rich vegetable oils in preparation of CR components. Suitable components include the main meals, muesli mixes, fruit cake, instant noodles, ADF specific food bar e.g. FSB. COTS products: - investigate suitable vegetable based (not potato) snack products; - replace current tuna varieties with tuna stored in vitamin K rich vegetable oil e.g. olive oil.
Iron	Chocolate beverage powder, main meals, cereals and high fat confectionery	COTS products: - investigate the suitability of COTS cereal products, such as ready-to-eat breakfast cereals and muesli mixes, fortified with iron, for inclusion in CR. Fortification: - fortification of main meals and cereal based products.

		- fortification of flour with iron, used to produced flour based products such as biscuits and noodles. - fortification of spice sachet for the instant noodles.
Calcium	Dairy, main meals, high fat confectionery and cereals	COTS products: - investigate commercially available products suitably fortified with calcium for use as CR components. Potential products include ready-to-eat breakfast cereals, muesli mixes, powdered milks, flavoured beverage powders (e.g. sports formulated products). Fortification: - investigate the fortification of components that meet voluntary fortification criteria of the Code (e.g. soup powder, sports beverage powder, chewy gum).

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19. ABSTRACT

Health Systems Program Office (HLTHSPO), Defence Materiel Organisation (DMO) requested the Defence Science and Technology Organisation (DSTO) to verify the requirement for fortification of Combat Ration (CR) components and identify options to improve the nutrient composition of Combat Ration Packs (CRP). Prior to the implementation of significant improvements, the nutrient composition of CRP was determined. A number of nutrients were not present at recommended levels. Priority should be given to rectifying inadequate levels of protein, folate, vitamin B6, vitamin A, vitamin E, vitamin K, iron and calcium. The availability of thiamin, vitamin B12 and vitamin C is of some concern and improvements are needed. The vitamin D content of CRP should be assessed as levels are currently unknown.

The findings will inform HLTHSPO's ongoing CRP improvement program. Options to improve the nutritional quality of CRP include: re-configuration of the suite of rations; Defence specific component formulation (Military-Off-The-Shelf); increased use of Commercial-Off-The-Shelf products; fortification; and combinations of these options.